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Reinforced-Concrete Building of the Phelps Publishing Co., Springfield, Mass.

By ARTHUR C. TOZZER*, C. E.

A large reinforced-concrete building was built last summer for the Phelps Publishing Company at Springfield, Mass.

It consists of an eight-story reinforced-concrete skeleton with concrete walls, partitions and parapets. The ground-plan dimensions are 285 × 105 ft., and the height above the curb to top of roof houses is 125 ft. The eight main stories, basement, sub-basement, roof houses and galleries give a total floor-area of about 7½ acres. The treatment of its exterior is modeled after the Royal Palace at Stockholm in its details. An unusual feature of the exterior is the nature of the finish given to the concrete, which is noted farther on in this article.

Special conditions led to the adoption of reinforced concrete for this building. The old plant of the Phelps Publishing Company was housed in a group of some ten old buildings, one to five stories high. This was entirely destroyed by fire on January 28th, 1907. Rebuilding had to be undertaken at once, since in a publishing business an interruption of operations means considerable loss, more than in most other lines of activity. Temporary provision being made elsewhere for publishing the different periodicals which constitute the company's business, and the owners having promptly decided to put up a modern office building which would be thoroughly up to date and a worthy monument to their

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NEW BUILDING OF THE PHELPS PUBLISHING CO., SPRINGFIELD, MASS.
Five Stages of Construction Work Progressing Simultaneously.

business, reinforced concrete was selected as the material for the new building because it offered the most rapid construction and at the same time was economical, absolutely fireproof, practically without vibration, and sanitary both as to vermin and water damage. With this material it was possible to begin reconstruction at once, constructing the footings before the structural details of the rest of the building were worked out. It was unnecessary to get out detailed plans for columns and floor beams and wait for them to be fabricated at the mills and shipped to the job. Given the floor loads and a general layout of the building the size of footings could be determined with safety and work undertaken as soon as the ruins of the old plant were cleared away.

The construction work had to be carried on with the idea of allowing the large Hoe and Cottrell newspaper presses, which had been saved from the fire and were running on their old foundations, to operate without interference. For this reason work was started on the west end of the lot on June 4, 1907, and a section of building, 60 × 105 ft. in plan was run up three stories over a press room 31 ft. 10 ins. in clear height which occupied the rear portion. While this construction was under way the work of moving one of the large presses was started, and after this was set up and running the second was similarly moved to its new quarters. The result of these operations was that the entire lot could not be turned over to the contractors until Aug. 18. The photograph reproduced on the preceding page shows how the work was arranged in successive stages in consequence.

The excavation of the entire rear half of building was carried down 23 ft. below the sidewalk curb level to accommodate the boiler and engine rooms. This required heavy shoring along the rear building line, where a number of five-story brick buildings come within 10 ft. of the line of excavation. The front of the basement has its floor 18 ft. below curb level. Water was encountered at a level of 21 ft. below curb, so that extensive sheeting and pumping was necessary for all of the deeper foundations. The soil is a fine running sand, very wet, which required not only careful work in excavation, but also full provision for waterproofing and permanent drainage.

The progress of construction for the floors and walls after the whole area was under way was at the rate of a story every nine days; five stories, however, were constructed in thirty-one working days (each floor having an area of about 30,000 sq. ft.).

DESIGN.—The entire structural design followed the usual system of the Turner Construction Company. Footings were designed for a bearing value of 3 tons per sq. ft. The interior footings are generally 11 ft. 2 ins. square and 3 ft. 6 ins. deep, pyramidal in shape (see typical sketch in Fig. 3), reinforced with 1-in. square twisted bars. The five lower floors were designed for a live-load of 200 lbs. per sq. ft., and the others for 150 lbs. The roof was proportioned for 100 lbs., to take care of special structures such as photograph gallery, dining hall, penthouses, promenade, etc.

Typical girder and beam sections are shown by detail sketches in Fig. 3. At the junction of girders with columns there are brackets 12 ins. long, 18 ins. deep, the full width of the girder, to give additional stiffness.

The interior columns are of approximately octagonal section except that the faces to which the girders are connected are maintained a constant width to facilitate the construction of the wooden forms. The columns vary in size from 31 ins. in diameter in the basement, changing section every two stories, to 14 ins. square in the eighth story. The reinforcement consists of spirals of ⅝-in. and 7/16-in. hard-drawn steel wire, of varying pitch and form, and longitudinal round rods varying in size from ⅞-in. to 1⅛-in. diameter, the longitudinal rods being made continuous by screw or pipe couplings. The exterior columns on the three front sides of the building are very variable in shape and size to allow for architectural treatment. The columns of the rear wall are rectangular. About half of the rear wall columns are used as flues for conveying warm air from the basement to various floors, the building being heated entirely by air blast heating. The flues are formed integral with the columns, the column forming the front of the flue, in fact, while a 6-in. shell forms the other three sides. The flues vary from 12 × 12 ins. up to 32 × 37 ins. No great loss of heat through the concrete shell is noticeable. The rear wall flues supply heat to about half the building, while interior flues supply the remaining parts of the building.

The floors consist generally of a 4¼-in. slab, spanning about 6 to 6½ ft. between the beams. The slab is reinforced with 5/16-in. square twisted bars. All floors excepting the first have a 1-in. granolithic surface, applied a[s] slab is in place, with an acid join[t] mix of concrete was employed in [the main] and girders, and a 1:2:3 mix in col[umns] [1:2½4] [beams]

The exterior girder at the third flo[or] [vel over] the main entrance has a clear span [2 ft. and] carries a total load of 582,000 lbs., [greater] portion of which is a concentrated [mn load] at its center, as well shown in the [ral view]

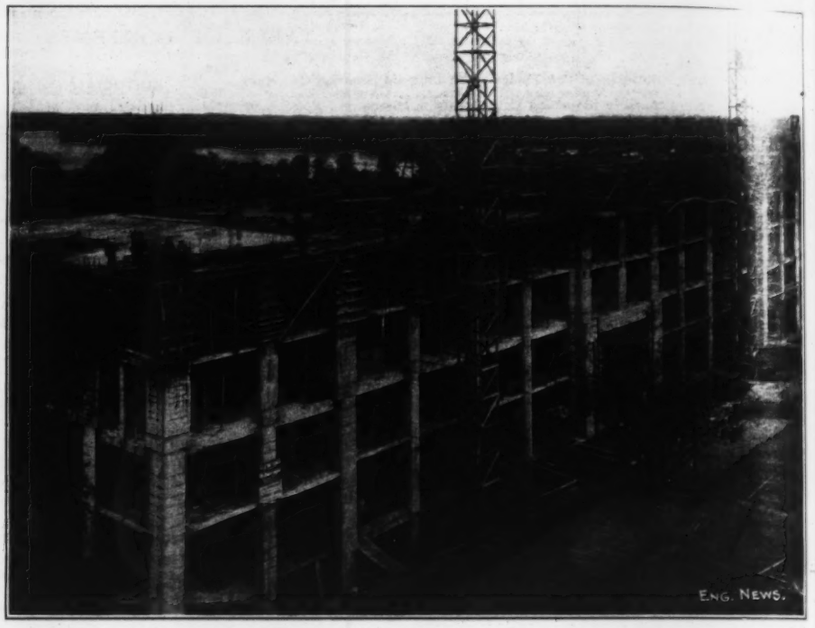


Fig. 1. Working on the Fifth Story.

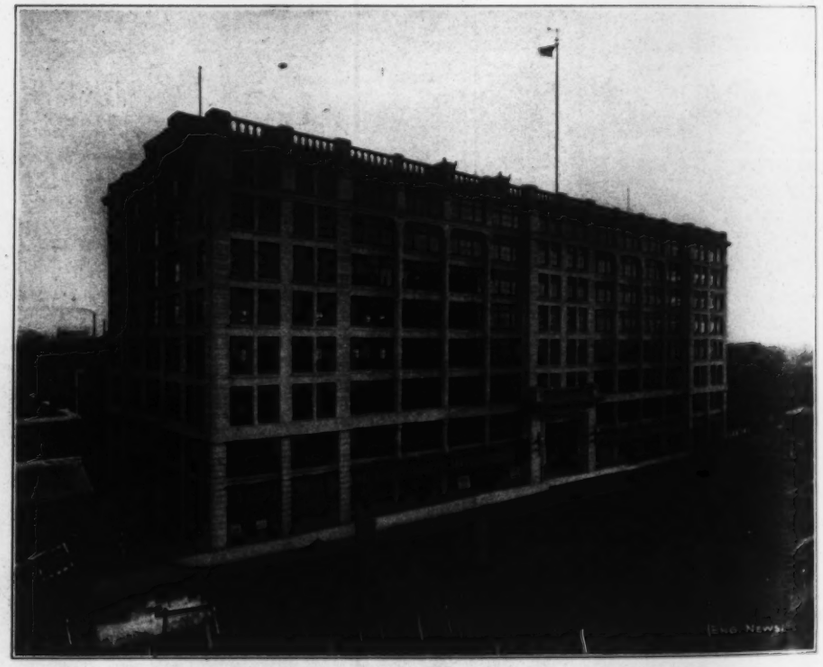


Fig. 2. The Building Completed.

FIGS. 1 AND 2. THE NEW BUILDING OF THE PHELPS PUBLISHING CO.

Fig. 2. The forms for this girder, with the reinforcement in place, are shown in the view Fig. 5. The general dimensions of the girder and its supporting columns are given in Fig. 4. The girder is 24 ins. in width by 7 ft. in depth, with a flare at the top 24 × 24 ins. The reinforcing steel consists of twenty-two 1⅛-in. square cold-twisted bars and forty ½-in. stirrups; the latter

act also as ...ds to hold on the cornice, which was built ... The supporting columns are of even more ...egular shape than the girder, as Fig. 4 shows. Their great width, about 10 ft., is for architectural effect.

A heavy ... course surrounds the street fronts at the ... floor line. It was cast monolithic with the ...tain walls, bonds being left on the column ... The belt-course at the eighth floor line, ... curved column tops, etc., was cast monolithic ... the floor slab. Bonds and recesses were left in the construction of the face beams at the roof line to provide for attaching the main cornice. The balustrade around the roof, 3 ft. high, was cast in three parts: base, balustrade and top rail, and erected as the cornice was finished. A ⅝-in. vertical rod runs through each baluster, having a hold in a recess in the base and extending into the top rail, which was cast after the rod was grouted.

FACE FINISH.—The architectural effect of the completed building is very pleasing, as it lacks the usual plainness of a reinforced-concrete building, although no effort has been made to hide the identity of the material employed, and although about 60% of the wall surface is windows. Various surface groovings were used on the exterior surfaces of the columns, being produced by cleats on the inside of the forms. In finishing, the plane surfaces were first pointed up, the more noticeable board marks removed, and the surface then painted with "Grady's Sand Finish," a new preparation invented by the contractor, which gives the building a uniform appearance and assists in making the concrete impervious to water. The uniform color obtained by this method may be judged from the view of the completed building, Fig. 2.

WATERPROOFING AND DRAINAGE.—Some very interesting problems were brought up and successfully carried through in dealing with water in the basement. The general water level was so high, as has been stated, that pumping was necessary for all foundations in the rear portion of the building. Here two footings were inclosed in a single cofferdam, the suction of pump being placed midway between them, and were concreted simultaneously. Several of the footings were raised, in order to hasten the work, so that their tops projected some 2 ft. above the sub-basement floor.

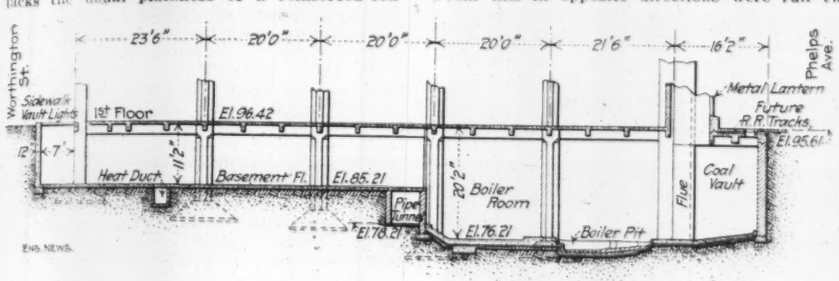
The waterproofing, of five-ply felt and "Sarco" compound, was put in at an elevation approximately 2 ft. under the normal water level, necessitating some efficient means of underdrainage both for placing the 3-in. concrete mat on which the waterproofing is placed and later for the application of the waterproofing. The extremely abundant flow of water through this sand made the undertaking of considerable magnitude. The bay between the four deepest footings in the boiler room was chosen for the location of a central sump. The sump was designed as a concrete box 4 × 4 ft., with 6-in. reinforced walls. From this in opposite directions were run two lines of 6-in. terra cotta pipe over the whole area to be waterproofed. Branch lines of 4-in. pipe in every transverse bay drained into the 6-in. pipes and these to the sump, all being laid with a pitch toward the sump, joints wound with burlap, and the ditches backfilled with crushed stone in order to give the ground water free access to the drains. The sump was taken care of by a 5-in. Heald & Sisco centrifugal pump, and it was found that a discharge of about 800,000 gals. a day would lower the level of the groundwater about 3 ft. over the whole area covered by the drains. With this new level of groundwater the application of the waterproofing became an extremely simple task.

The heavy concrete floor acts as a gravity seal for the waterproofing. Its weight is sufficient to withstand the upward pressure of the water until it reaches elevation 78.21, the highest point to which the groundwater has been known to rise. However, the proximity of the Connecticut River with its spring floods called for some safeguard against a possible higher level of water. For this reason the same open-jointed drains that had been used during construction were now given a permanent use as a safety valve against excessively high water. To accomplish this the sump was permanently closed by a 6-in. cover slab, and a 6-in. pipe run upward through the top, turning horizontally at elevation 78.21 and discharging into an open sump of boiler-iron, which serves also as catch-basin for several floor drains, drips, etc. Water will not be discharged from the closed sump until it reaches elevation 78.21, when it will be forced over the bend in the pipe and discharge into the open sump. From here it is removed by a centrifugal pump driven by electric motor, started automatically. No overflow from the closed sump has yet occurred. Fig. 8 shows the two sumps in vertical section.

In setting the four 250-HP. boilers it was necessary to go considerably deeper with the ash pits than was originally intended. This endangered the adjacent column footings, as sand boiled up from under their bases when the pit excavation was still 10 ins. above their level. To overcome the problem of holding the material, and to get a bed for the waterproofing in the bottom of the pits, boats of ⅛-in. sheet lead were built to the exact shape of the pits and enough larger to allow for a concrete lining (Fig. 8). These tanks were built on ways and launched like an ordinary boat and floated into place. Each tank weighed about 1,500 lbs. (later sheet-iron tanks were used at a slight saving in cost). Greater speed was thus possible and at less danger and cost than by putting down a preliminary mat and using ordinary tar-and-felt waterproofing.

There are six plunger elevators and four stairways, the latter being of reinforced concrete with metal treads. Elevators and stairs are enclosed in 4-in. concrete partitions, and all doorways are provided with automatic fire doors, the sills of which are raised 1-in. above the normal floor level to prevent flooding of lower floors in case of fire. Scuppers are also provided in the rear curtain walls for the same purpose.

The building is heated by the Sturtevant blower system through flues under the basement floor to vertical flues, those on the rear being formed along the columns, as already described. The fresh air is drawn from a hood on the roof, 125 ft. above the street. Electric current for lighting and power is furnished by a plant of 1,000-KW. capacity in the basement and dis-



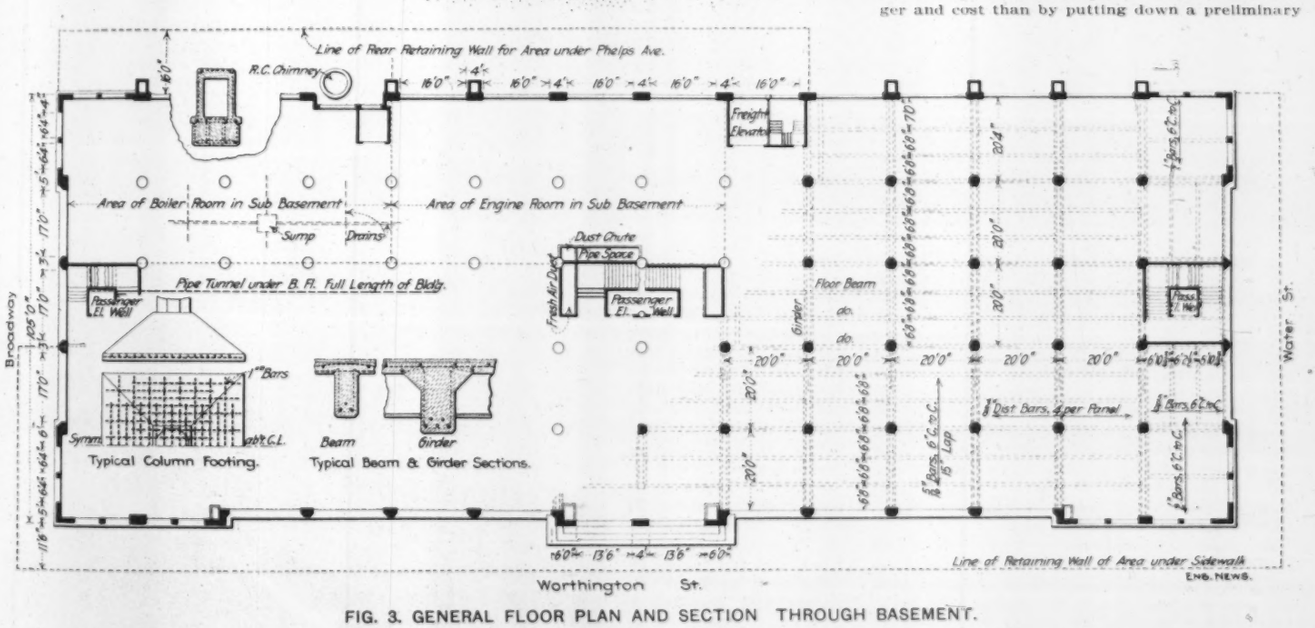


FIG. 3. GENERAL FLOOR PLAN AND SECTION THROUGH BASEMENT.

tributed through wires run in conduits laid in the concrete floor slabs, the main risers running up the fresh-air flues. Complete control of every part of the building is thus had from a switchboard in the basement.

To provide for additional wires, etc., holes were left in the concrete beams and girders. To take care of piping and shafting which would be hung from ceilings, cast-iron spools tapped for bolts were set in the floor-slab flush with the ceiling. All water, soil and other pipe risers are carried in a pipe shaft located in the middle of the building. Each toilet room is provided with a pipe chamber just back of the closets, which, with raised floor, allows all pipes to be concealed. Rubbish and dirt from various floors is carried to the basement in a chute provided with fire doors. This reduces the fire hazard greatly, and by depositing all the debris in an airtight chamber makes the structure an extraordinarily clean one. The building is equipped with all the modern office building devices for commercial service.

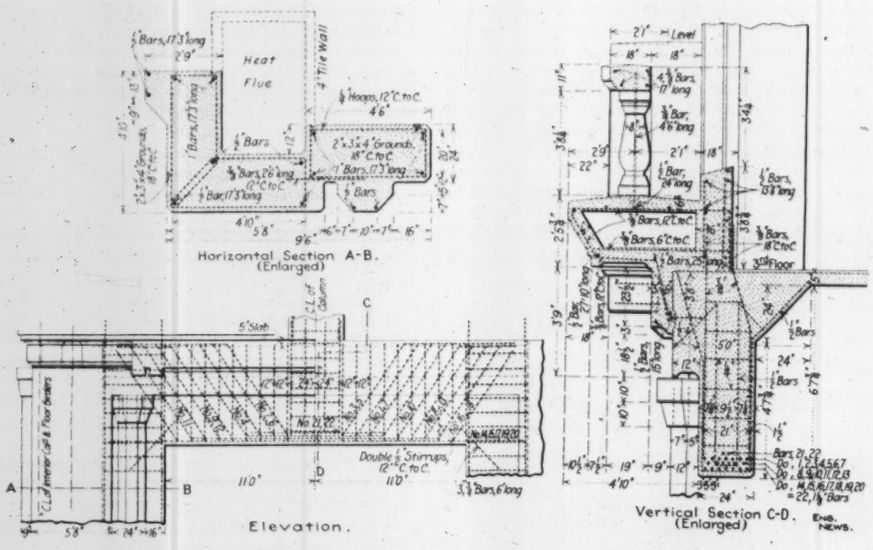


FIG. 4. DETAILS OF ENTRANCE COLUMNS AND GIRDER.

In Fig. 1 is shown a general view of the building during construction. The mixing plant consisted of a No. 3 Ransome mixer in the basement with an ordinary Ransome bucket box and hoist. Power was furnished by a 40-HP. motor belt-connected to hoist and mixer. Sand and stone were dumped through the first floor close to the mixer. All steel was fabricated on the first floor after work was under way. Steel and forms were hoisted from floor to floor by three portable power-driven cranes which were moved from floor to floor as work progressed.

Mr. Fred S. Hinds, Boston, Mass., was Architect for this building. The Turner Construction Co., New York City, was the General Contractors, and also designed the reinforced-concrete work. Mr. Herbert Myrick, President of the Phelps Publishing Co., had general charge of the work for the owners.

THE MUNICIPAL INDEBTEDNESS OF ENGLAND and Wales (excluding London and the rural districts), according to Local Taxation Returns for the year 1905-06, amounted to $1,168,110,000. The returns include 72 counties and 254 other boroughs outside of London. The debt is divided, as to its main items, as follows:

Water-works	$286,871,000
Public roads and streets	132,108,000
Tramways and light railways	101,505,000
Electric lighting	97,412,000
Sewerage and sewage disposal	97,038,000
Gas-works	95,448,000
Education	88,650,000
Harbors, piers and docks	35,318,000
Parks and open spaces	25,552,000
Housing of the working classes	25,055,000

The foregoing tabulation accounts for $984,957,000 out of the total of $1,168,110,000. The total indebtedness of the 326 boroughs averages nearly $83 per head. These figures have been taken from a brief summary published in the London "Surveyor" for Jan. 8, 1909.

Experiments with Automatic Stops and Cab Signals in Germany.

The use of automatic stops and cab signals as auxiliary or supplementary to the regular block signal system was reviewed in our issue of Jan. 14, in connection with the report submitted by the Block Signal and Train Control Board to the Interstate Commerce Commission. In the January number of the "Bulletin" of the International Railway Congress Association we find an abstract of an interesting paper by Captain Gonell (of Berlin) on German experiments with safety devices intended to prevent trains from over-running stop signals. He points out that the danger increases with the growth of traffic, the increase in speed, and the shortening of the intervals between trains. Consequently, the railway administrations have been engaged in working out devices to reduce this danger, and extensive experiments with such devices are being carried out on the Prussian State Railways.

TORPEDOES. — These are now in general use, but present two disadvantages: (1) the light and sound produced may not be noticed by fast trains, which themselves produce much noise; (2) the torpedoes have to be placed and removed by hand. Attempts are being made to overcome these disadvantages by using more powerful torpedoes and introducing mechanical appliances. It is not always possible, however, to connect the torpedo-placing device with the signal wire, as it would put too heavy a load on the wire. In such cases a special watchman is required, upon whom all reliance must be placed.

ELECTRIC HORNS.— These are intended to give audible notice that the train is approaching a signal indicating "stop." One is placed 328 ft. and another 65 ft. from the distant signal, with a contact 65 ft. in advance of the first horn and another at the home signal. [illegible] arranged in an electric circuit fed [illegible] located in the signal box. The [illegible] normally open, and is closed only [illegible] age of a train. The second contact [illegible] connected into the signal transmission [illegible] way that the circuit is closed when [illegible] indicates "stop," but it is open when [illegible] indicates "clear," so that the horns [illegible] sound. A train approaching a "stop" [illegible] pletes the circuit, and the diaphragms [illegible] of telephones) in the horns are set [illegible] so as to give out a loud grunting [illegible] are being made to determine if the [illegible] clearly audible on the engine, and [illegible] their position upon their audibility.

ELECTRIC SIGNAL INDICATORS. [illegible] devices placed in the engine cab to [illegible] engineman when he is approaching [illegible] gardless of the signal indication. [illegible] tended only to warn the men to [illegible] the signals, and Capt. Gonell consi[illegible] important feature. A contact rail at [illegible] the track engages with a shoe on the [illegible] contact faces being vertical in order [illegible] against the accumulation of snow, etc.

STATION RECORDING ALARM. This apparatus is intended to inform the station officials if a driver runs past a signal standing at "danger," and at the same time to record how often such an event has taken place. The apparatus is located in the office of the station building or in the signal cabin, and forms part of an electric circuit fed by a battery. When a train passes a rail contact, the circuit is closed and the alarm is set ringing. This is arranged so as to continue ringing until it is stopped by the official in charge, consequently the occurrence cannot pass unnoticed. In stopping the alarm, a counter is operated simultaneously, and a figure appears behind a small window in the case, recording the number of times the over-running of the signal has occurred. As the fact that such an event has occurred is at once brought to the knowledge of the station-master, he is forthwith able to investigate the subject by examining the engineman and fireman, or in case of a train that does not stop at that station, he can telegraph to the next station at which the train stops.

AUTOMATIC TRAIN-STOPPING DEVICE.—

FIG. 5. ENTRANCE GIRDER REINFORCEMENT IN THE FORMS, READY FOR CONCRETING

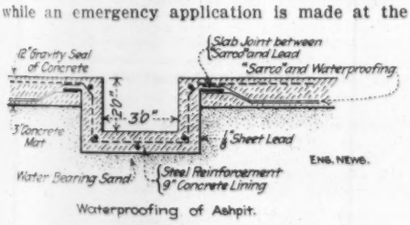
(This girder is at the third story level. It carries a 250-ton column load at the center.)

The paper g[illegible] into some detail in describing the Van Braam [illegible] apparatus, which not only gives visible and [illegible]ible signals on the engine but applies the b[illegible]kes if the engine passes the signal when at the "stop" position. It is one of the mechanically operated devices under trial. Trips on the lo[illegible]otive put in motion mechanism which (1) [illegible]plays signals in a box in the cab, (2) opens a special whistle, and (3) operates a brake valve. When the signal is put at the "stop" position, contact bars or treadles in the track are raised so as to engage the trips. There are separate sets of treadles and trips. Thus the cab signals indicate whether a distant or home signal has been passed, and an ordinary application of the brakes is made at the former while an emergency application is made at the latter. If the engineman sees the distant signal go to the "clear" position, he can release the brakes, and can mark the diagram by means of a push button, to show that he has seen the signal. Portable treadles can be used to protect trains which are stopped by accident.

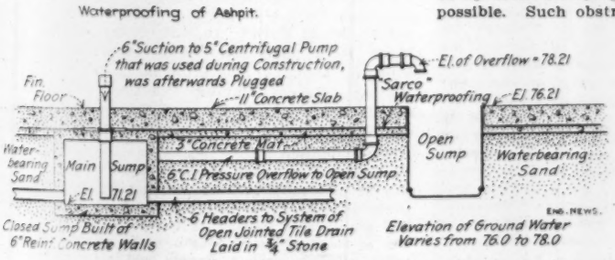
The apparatus is purely mechanical, and seems to be somewhat complicated in order to give so many indications. It is stated by Capt. Gonell, however, that the mechanism was designed for these manifold functions by the inventor, in order to satisfy the conditions contained in a specification of the French department of public works. The trials will show whether all of them are necessary, or whether some can be omitted, in order to simplify the mechanism, without affecting the safety of the traffic. The application of slipper contacts for releasing the mechanism is of itself new, and has often been utilized before. But the Van Braam apparatus is said to have this superiority over similar appliances, that whereas with the latter, the contact of one slipper only suffices, with the former, both the slippers of a pair must come in contact with the rails simultaneously, before the mechanism can work. If only one slipper comes in contact, nothing happens. This materially increases the reliability of the mechanism, as any accidental release produced by irregularities in the ballast or by tools left lying by the track is almost impossible. Such obstructions would have to exist on both sides of the running rail, at an equal distance and an equal height.

Trials of this apparatus were first made on French railways, and in Prussia by the administration on the Government military railway. Good results were obtained, and the apparatus could be readily examined and looked after by the staff concerned. A report of the results obtained on the Prussian State Railways was published by Mr. Klopsch, civil engineer, in the Zeitung des Vereins Deutscher Eisenbahnverwaltungen," for Feb. 12, 1908.

FIGS. 6 AND 7. THE FRONT ENTRANCE, IN THE ROUGH, AND FINISHED.



Waterproofing of Ashpit.


6" Suction to 5" Centrifugal Pump that was used during Construction, was afterwards Plugged
El. of Overflow = 78.21
Fin. Floor
11" Concrete Slab
Sarco Waterproofing
El. 76.21
Water-bearing Sand
Main Sump
3" Concrete Mat
6" C.I. Pressure Overflow to Open Sump
Open Sump
Water-bearing Sand
El. 71.21
ENG. NEWS.
Closed Sump Built of 6" Reinf. Concrete Walls
6 Headers to System of Open Jointed Tile Drain Laid in ¾" Stone
Elevation of Ground Water Varies from 76.0 to 78.0

Section through Drainage Sump.

FIG. 8. DRAINAGE SUMPS AND ASHPIT WATERPROOFING.

AN UNBALANCED BID of somewhat remarkable character has come to light at Chicago and is causing much unpleasantness in the municipal departments. For some years the annual contracts for repairing asphalt streets have been secured by certain contractors at prices ranging as follows: For resurfacing with asphalt only, 89 cts. to $1.32 per sq. yd.; for 6-in. concrete base, binder and asphalt resurfacing, $1.49 to $2.50 per sq. yd. Last year, however, the accepted bid was $1.75 per yd. for resurfacing with asphalt alone (an exceptionally high price); and 1 ct. per yd. for entire reconstruction. The work has included a large amount of resurfacing and a small amount of reconstruction, so that the city is said to have paid $100,000 more for the work than if the work had been let to other contractors at reasonable figures. The matter has been called to the attention of the Commissioner of Public Works, who is conducting an investigation in order to ascertain how the contractor came to make such a peculiar bid, and why this bid (so obviously peculiar) was accepted.

POOLING IN BUILDING CONTRACTS seems to be a common thing in Germany, judging from a court decision recently published in the "Zentralblatt der Bauverwaltung." The case was an appeal of a contractor's suit for balance due. He had contracted to build a warehouse for some $45,000, securing the job as lowest bidder among eight. But the owner found that before bidding this contractor had called a meeting of the other seven, and agreed to pay each of them $750 if he was awarded the contract, the other bidders to submit bids higher than his. On the basis of this agreement he bid about $4,000 higher than his estimate, it is alleged, and received the contract. The owner withheld from the final payment an amount equal to the excess of the bid over what was claimed to be the lowest estimate price mentioned at the pool meeting, some $7,000. The contractor admitted the pool agreement to leave the job to him for a consideration of $750 to each, and claimed this permissible because a common custom. The court confirmed nearly the full claim of the owner, and except for a minor change in the amount at issue it denied the contractor's suit.

THE HUMBOLDT NATIONAL FOREST in Northern Nevada has been extended by 600,000 acres by a proclamation signed by President Roosevelt on Jan. 21. This increases the area of this reservation to about 1,160,000 acres.

Creosoted Wood Block Pavements.

Creosoted wood block paving work was dealt with in two papers and a committee report submitted before the annual convention of the Illinois Society of Engineers and Surveyors, in January, 1909.

Experience at Grand Forks, N. Dak.

Mr. J. J. Smith, City Engineer of Grand Forks, N. Dak., read a paper which we have rearranged and extended (by additional material from Mr. Smith), as follows:

In 1908, the city of Grand Forks, N. Dak., laid 37,400 sq. yds. of creosoted wood block paving, the work being done between Aug. 22 and Nov. 19. This replaced an old paving of cedar blocks; the old blocks were 6 ins. deep, laid on a course of 2-in. plank and on a 2-in. bed of sand.

The specifications for the new work required that the blocks should be 3½ ins. deep (parallel with the fiber of the wood), 3 to 4 ins. wide, and 5 to 10 ins. long (averaging 8 ins. long). The blocks received were 3½ ins. wide. It was considered that the blocks should be treated with at least 16 lbs. of creosote oil per cu. ft., but those used were given an average of 20 lbs. per cu. ft. The creosoting was done by the Kettle River Quarries Co. at Sandstone, Minn. The blocks were cut from Norway pine and tamarack. The latter proved to be of better quality, and appeared to take the treatment more readily than the pine. The tamarack blocks contained but few knots, and scarcely any of them were checked or warped.

Some cities have reported that treated wood block pavement has swelled, buckled or raised up after rains. We have had no such experience with our pavement so far, although it was set in place during the very dry

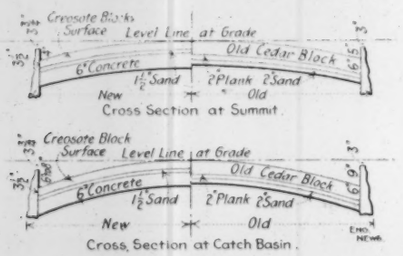


Fig. 1. Cross-Sections of Streets with Wood Block Paving; Grand Forks, No. Dak.
(J. J. Smith, City Engineer.)

weather, and we have had enough showers since to cause swelling, if such could take place.*

As to slipperiness, the paving has been in place for only a short length of time. We received bids on ten different kinds of paving, and the question of slipperiness was considered. The weather being chilly, we had difficulty in filling the joints with tar, and a slight scum of tar remained on the surface of the blocks. As this tar hardened, the surface was somewhat slippery and occasionally a horse went down, the horses being shod with the ordinary shoes. When a horse happens to slip, the surface is so smooth that it is difficult for him to recover himself before falling.

The sand which we spread over the surface was of great assistance in affording a foothold. After the pavement was in use a very short time the slipperiness from the tar on the surface disappeared. The contractor's horses which hauled the creosote blocks and the sand to place on the surface of the pavement were shod in the ordinary manner, and there was only one horse which appeared to slip. I never saw him go down, but he became very nervous when he had to travel over the freshly tarred surface. Careless driving was the cause of most of the falls. Horses going for the first time on the pavement realized the difference between the old cedar block pavement and the creosoted block pavement, but the farmers would drive unshod horses into town with loads of hay and I did not see any of them slip or fall. We had a few rainy days, but this did not seem to make the pavement slippery.

As each block of new pavement was opened for travel there was clay and other foreign material carried on to the surface. This, especially during cold weather, slightly roughened the surface and improved the foothold. We hardly ever have sleet, but the pavement has been covered with snow for some time. As we will have over 50,000 sq. yds. laid on the streets in the business district, all connected, the horses will soon get used to the pavement.

We made a special study for elevations at each intersection of paved roadway, and set sub-grade stakes with a Y-level so that our plans would be carried out and the surface of the pavement would be such that horses would have a good surface on which to make turns. I believe this pavement will not be slippery in hot weather. The Fire Department has made several runs over the pavement and is well pleased with the results. The horses have never fallen down. They have "neverslip" shoes.

We specified a sand cushion 1½ ins. thick before compression by the roller, but we may change to 1¼ ins. for 1909. The sand cushion should not be too thick, and our experience shows that it should be of as even a thickness as possible, but should be thick enough to allow for the irregularity of the surface of the 6-in. concrete base. The concrete was a 1:3:6 mixture of Portland cement, sand and gravel.

The pit gravel was screened, and any passing a ¼-in. mesh was considered as sand. We experienced trouble in screening the gravel, and the ordinary building screens of ¼-in. mesh would not stand intact for a single day. Screens were procured of the same mesh but larger wire. Still, when the gravel was damp, or the percentage of sand large, all of the sand would not go through the screens, but would pass over and become mixed with the aggregate. Another change was made to screens of 5/16-in. space made from No. 16 wire. This proved more satisfactory, although some rather coarse grains passed with the sand.

All gravel was thrown from the railway cars onto the screens, each 10 × 10 ft. It was first thrown against the screens from the front in the usual manner; then the screens were set with the top ends against the cars, and the gravel was thrown upon them from the rear. Judging from this experience, we believe the pit gravel should be screened, as the percentage of sand is too large in the pit gravel found in this locality.

All concrete was mixed in a mixer, enough water being used so that the concrete when deposited in place was in a very mushy condition. The mixing machine was placed at each intersecting street, making the longest haul about 400 ft. The concrete was hauled from the machine in one-horse concrete spreader cars. From five to seven days were allowed to elapse before the paving was placed upon the concrete.

Vitrified 4-in. tiles were placed immediately underneath, and 3 ft. below the top of the curb, and the trench up to the curb was filled with pit gravel. Subdrains 18 ins. deep were excavated in the clay soil and filled with gravel. These were 50 ft. apart, and extended from curb to curb. The soil at subgrade was rolled with an 8-ton tandem roller with rear tire 44 ins. wide and 54 ins. diameter; 265 lbs. pressure per lin. in. of tire. The wood block wearing surface was rolled with the same roller before tarring the joints, in order to compress the sand cushion and to give the pavement a smooth surface.

Tar was used as a filler between the wood blocks, and for the expansion joints. These joints were placed across the street, ⅝-in. wide and 100 ft. apart, and also 1-in. wide along each curb. We experienced difficulties in filling the joints with tar, as the blocks were laid close and the temperature was chilly at the time the work was done. By using large kettles and heating the tar to about 600°, and by better efficiency of the men, we accomplished better results, although a second pouring of tar was in some places required to fill the joints.

After the tarring was completed, a coat of fine sand was spread over the surface and swept so as to (where necessary) work into the joints and also temporarily give a gritty surface where a thin scum of the tar had chilled and adhered to the top of the blocks.

The rows of treated blocks were placed at an angle of 67½° with the curb line, except that at the street intersections they were laid at right angles with the curb line of the intersecting street from the curb line on the street being paved to the property line of the same. Adjacent to the curb, one row of blocks was laid parallel therewith. Kettle River sandstone 5 × 20 ins. was used for curbing, and the same stone 4 × 16 ins. for headers.

The streets are 80 ft. wide and the paved roadway 50 ft. wide. The surface of the paving at the center of the street is 4 ins. above the curb, as shown in Fig. 1. On one street having a double-track street railway, however, it is of same elevation as the curb. The gutters at the summits are from 3 ins. to 4 ins. below the top of the curb, and at the valleys or water inlets they are from 6 ins. to 8 ins. below it. Summits are necessary in the gutters, as most of the streets are level lengthwise. The very high crown could not have been used except for these summits in the gutters. The 4-in. crown in a 50-ft. roadway was the maximum, and a less crown would give satisfactory results.

The street intersections, Fig. 2, are raised 8 ins. above the curb at the intersection of street centers, and along the center of each street there is a gradual fall for 50 ft. to the normal level where the elevation is 4 ins. above the curb. The gutter is 2 ins. below the top of curb at intersecting curbs, 3 ins. to 4 ins. at the property line, and 6 ins. to 8 ins. at the water inlet at valley which is placed 10 ft. (or more) from the street intersection. This condition allows as safe and the street intersections are as safe as any other part of the street for vehicles. There is a step of not more than ½ in. from the top of the curb or sidewalk to the gutter. The paving for pedestrians in crossing the street should intersect with a radius of not less than 10 ft.

The city employed four inspectors, one at the creosoting plant (who made itemized daily reports of treatment to the city engineer), one at the mixing machine, one where concrete was deposited in the street, and one with the gang laying the wearing surface. Although the contractor showed every disposition to do good work, we believe the money paid for inspection was a good investment.

An electric street railway track was laid in the street ahead of the concreting. Part of the track consisted of 4¼-in. 56-lb. T-rails on cedar ties 7 ins. by 8 ins. by 8 ft. placed 24 ins. c. to c. The remainder was of 4¼-in. 56-lb. T-rails on steel ties 4¼ ins. deep and spaced about 4 ft. c. to c. The steel ties were embedded in concrete. There were 4 ins. of gravel placed under the cedar ties. Concrete was placed between these ties, and finished level with the tops of the ties.

A decided improvement in the appearance and usefulness of the streets was made by changing the width of the sidewalks from 12 ft. to 15 ft. This allowed the use of side inlets instead of top inlets for the surface water entering the catch basins.

From Aug. 22 to Nov 3, three curb setters and four laborers set 5,400 ft. of new straight curb, 912 ft. of new circular curb, and 1,880 ft. of stone headers; they also removed and reset 7,800 ft. of old curb and all tile drainage underneath all curb. The contractor received 50 cts. per ft. for headers; 70 cts. per ft. for sandstone curb; 20 cts. per ft. for moving and resetting old curb, and $3.02 per sq. yd. for paving. This last included wearing surface, tar filler and expansion joints, sand top dressing and cushion, concrete foundation, excavating or trimming sub-grade, subsoil and tile drainage, and a two-year guarantee. Common labor cost $2 per day; cement about $1.70 per bbl., net; gravel on cars at city, $1.55 per cu. yd.

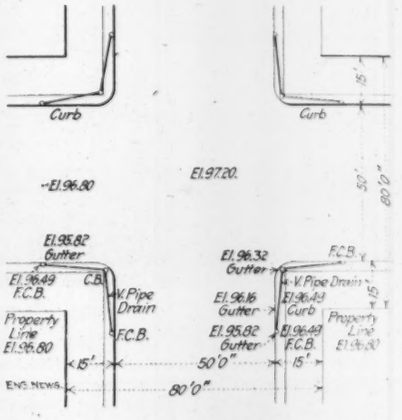


Fig. 2. Plan of Street Intersection, Showing Arrangement of Grades; Grand Forks, No. Dak.

Experience with Creosoted Block Paving in Chicago.

In the foregoing paper, reference is made to the swelling and buckling of wood-block paving, although such action has not been observed as yet at Grand Forks. In this connection, we give below some particulars as to experience of this kind in Chicago. This information is from a paper on "Recent Paving Practice in Chicago," which was read at the same convention by Mr. Jos. A. Moore, an engineer of the Board of Local Improvements.

Creosoted wood block paving is attracting much attention at present, largely on account of being comparatively noiseless. It is probable that the next few years will see a large number of the downtown streets, as well as many of the outlying ones, paved with this material. The pavements already laid are wearing exceptionally well, and are generally giving good satisfaction. The South Park Board has recently adopted this pavement for intersections of boulevards with streets having car tracks, the railway companies doing the paving in connection with the reconstruction of their tracks.

During the past season the writer had charge of the

*[Some further information on this point is given after the end of the paper.—Ed.]

paving of C... Grove Ave., from Oakwood Boulevard to 51st St. ... creosoted blocks. This was about 1½ miles, or ... sq. yds. The work was done by the Parker-Wa... on Co. at $3.44 per sq. yd. The blocks were treat... Norfolk, Va., by the American Wood Preserving ... Long-leaf southern pine, impregnated with an av... of 18.13 lbs. of oil per cu. ft. of timber was used. ... engineer was sent to the plant by the city to ins... the treatment. The blocks were 4 ins. wide and 4 ... deep, and were laid diagonally across the roadway. ... were laid on a 6-in. concrete foundation covered w... 1-in. sand cushion.

Expansion ... ats filled with coal tar were placed next to the cu... and at intervals of 50 ft. across the roadway. Th... eet has car tracks on it. One side was completed ... fore the other was torn up. The blocks were drive... nd wedged together fairly tight. Fine sand was used ... a filler. Expansion of the blocks due to the first ... squeezed the tar out of the joints, and considerable ... rouble has since been experienced by the blocks buckling during heavy rains. The part of the street which is behaving badly in this respect is confined to on... side of the street for a space of about four blocks. The reason why this part of the street buckles and other parts do not is not apparent, but is probably du... to some difference in the treatment of the blocks.

Sand is not the proper filler for creosoted block paving, being too pervious and inelastic. An impervious filler which will prevent any part but the exposed surface of the blocks from becoming saturated with moisture greatly lessens the liability of buckling.

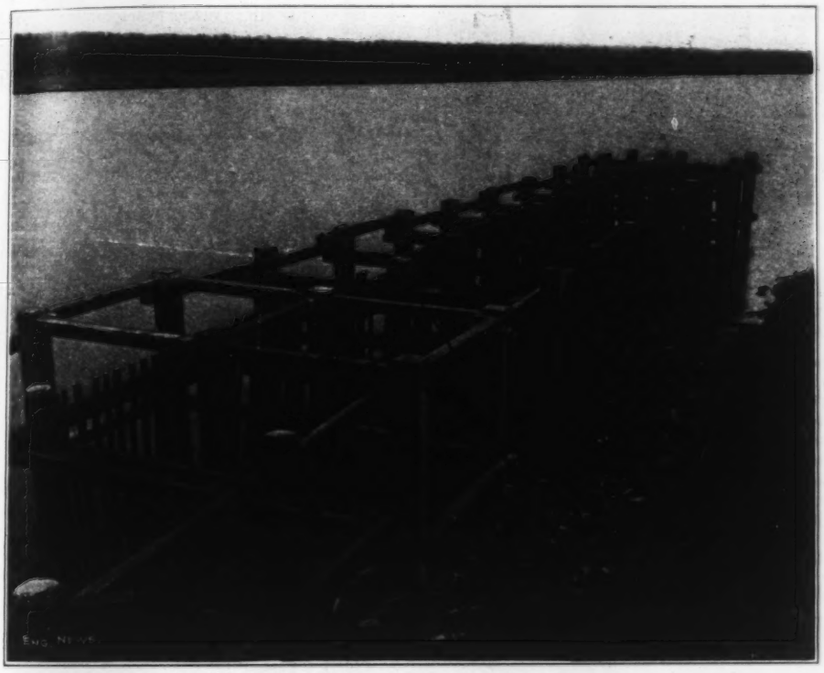
The report of the Committee on Roads and Pavements presented (together with the above papers) at the recent annual meeting of the Illinois Society of Engineers and Surveyors, stated that sand filling has not proved satisfactory for creosoted block paving in Chicago. From that report we quote the following paragraph:

> Creosoted wooden blocks laid during the past year, with a sand filler, have not proved a success. The blocks heave after almost every rainstorm, and the bed sand is often washed out of place. A wood pavement, no matter how well treated, must be protected from moisture getting under the blocks, and this cannot be done when a sand filler is used. It is claimed that traffic will grind dust and sweepings into the joints, and thus make them watertight, but there is room for doubt as to this. Sand being a rigid material, any expansion in the blocks cannot be taken up in the filler, and the pavement is forced up off the concrete. A tar or an asphalt filler is preferable. But even with a tar filler, the blocks should not be driven too closely together, nor should they be laid so loosely that traffic will fray the edges. In Chicago, an asphalt filler is preferred to a tar filler, on account of its not becoming so brittle in cold weather nor so soft in warm weather. It also retains its life longer than a tar filler.

Concrete Pile Dike on the Missouri River, Elwood, Kans.

The timber pile dikes built along the Missouri River have an average life of from 7 to 10 years. Usually the cause of their removal in that time is decay about the water line, but very often floods, floating ice and drift destroy them before they actually wear out. With the idea that concrete would resist both deteriorating influences of rot and exterior abrasive or destructive action, the United States has recently built at Elwood, Kans., near St. Joseph, Mo., on the Missouri River, a dike made of concrete piles, in order to test the value of concrete for such work. Through the courtesy of Capt. Edward H. Schulz, Corps of Engineers, U. S. A., who was in charge of the work, we are enabled to present some of the details of this experimental construction.

The proposals called for supervising the work of manufacturing the piles and for furnishing forms and reinforcing materials; the United States to furnish other material and to make and drive the piles. All piles were to be cast on the ground and were to be driven by jet and hammer combined. Under this specification bids as low as 80 cts. per lin. ft. were received. Methods of casting and driving different from those used were considered, but were discarded for various reasons connected with the peculiar conditions of the ground and the cost. The number of piles used was so small that any method involving any great amount of apparatus involved prohibitive costs.



A CONCRETE PILE DIKE FOR SHORE PROTECTION, BUILT BY THE U. S. ENGINEERS AT ELWOOD, KANS.

The following data give the most important details of the dike, shown completed in the accompanying half-tone:

Total length of dike, 150 ft., of which 40 ft. was timber nearest the shore, and 110 ft. of concrete piles.

Total piles driven, 36; total lin. ft., 1,457.

Length of piles, 32 to 50 ft.

Penetration, average 21 ft.

Elevation of top of piles, 10 ft. above standard low water.

Cross-section of piles, 14-in. square on top, 8-in. square at base.

Reinforcement—4 bars of 1-in. square steel, 1½-in. round tie steel, 18 ins. c. to c.

Forms, 2-in. yellow pine.

Mixture: 1 part cement, 2 parts Missouri River sand; 4 parts crushed rock, largest size, 1 in.

Weight of 50-ft. piles, 8,700 lbs.

Age: Set 10 days before driving.

The piles were cast on shore about 6 ft. above a barge, onto which they were skidded preparatory to being driven. On account of the weight of the pile a wire cable, with a single and double block, was used in the handling, slinging each pile at the large end and at about 15 ft. from the small end to take care of the deflection under its own weight. It was found that a pile could bow 5 ins. in the 50 ft. without injuring it.

In driving in sand only the piles were jetted down in about 5 minutes, by means of a jet attached to a 1¼-in. pipe fastened to the end of the pile. But in that part near the shore covered with rock and debris, considerable difficulty was experienced and a hammer had to be used.

At first it was intended to build the piles only of concrete, tying them together with timber, but in a portion of the dike concrete crossbeams were substituted for the timber, as will be noticed on the half-tone.

The actual cost to the United States was $1.36 per. lin. ft. of pile, which, after deducting the profit of contractor and cost of special supervision, would make the cost about $1.00 per lin. ft., a figure which could be expected to be reached by the government in future work. The itemized cost of the construction is as follows:

Invoice for supervising, forms and steel rods	$1,200.00
Portland cement, 86¾ bbls. at $1.25 bbl.	108.44
Crushed rock, 111,800 lbs., at $1.30 ton	72.67
Sand, 32 cu. yds., at 20 cts. cu. yd.	6.40
Labor, making forms	117.00
Labor, making piles	257.70
Labor, driving piles	215.00
	$1,977.21

The work has been only recently completed, and its behavior during the next few years will be watched with interest.

THE REUSE OF METALS has been studied by the U. S. Geological Survey in connection with its investigations of the broader subject of the conservation of the metals of the country. We quote as follows from a bulletin issued by the Survey:

> A part of these secondary metals is produced and sold as raw metal, but a very considerable portion is turned out as alloys, such as brasses, bronzes, babbitt, and type metal. The following table gives the results obtained by the canvass of the industry:

PRODUCTION OF SECONDARY METALS IN THE UNITED STATES IN 1907.

	Short tons.	Approximate value.
Secondary copper as raw metal and in alloys	30,240	$11,188,800
Secondary lead	9,990	
Recovered lead in alloys	15,508	2,702,788
Secondary spelter	18,841	
Recovered zinc in alloys	1,417	2,390,444
Secondary tin	93	
Recovered tin in alloys	1,569	914,404
Total		$17,196,436

This table is compiled from reports made by all smelters and refiners of secondary materials with whom it was possible to get into touch. Producers of such metals who have not received the Government requests for their production will contribute to the conservation movement as well as confer a favor by forwarding their names and addresses to the Division of Mineral Resources, U. S. Geological Survey, Washington, D. C.

THE MILEAGE OF RAILWAYS IN ALASKA is summarized as follows by the United States Geological Survey under date of Dec. 4, 1908:

	Miles.
Seward Peninsula:	
Seward Peninsula Ry., Nome to Shelton	80
Paystreak to Branch S. P. Ry.	6.5
Council City and Solomon River R. R., Council to Penelope Creek	32.5
Wild Goose Ry., Council to Ophir Creek	5
Fairbanks:	
Tanana Valley R. R., Fairbanks and Chena to Chatanika	46
Kenai Peninsula:	
Alaska Central R. R., Seward to near head of Turnagain Arm	53
Copper River:	
Copper River R. R., Cordova to Childs Glacier (Sept. 17)	47
(Probably 11 miles have been built since Sept. 17. Same railroad at Katalla, where there has also been some work done by a rival company, has built between 3 and 4 miles. At Valdez a few miles of track of the Alaska Home Ry. were laid in 1907.)	
White Pass:	
White Pass and Yukon R. R., Skagway to White Pass	20.4
(Terminal at White Horse, Yukon Territory.)	
Yakutat Bay:	
Yakutat Southern Ry., Yakutat to Situk River	9

Portions of the Council City and Solomon River and of the Alaska Central are out of repair and not in use.

Advance in Reinforced-Concrete Construction: An Argument for Multiple-Way Reinforcement in Floor-Slabs.

By C. A. P. TURNER,* M. Am. Soc. C. E.

Concrete construction when properly designed with suitable reinforcement is rapidly gaining in popularity due to its economy, its fireproof qualities, and the remarkable rapidity and safety with which it may be put up. As in all lines of construction work the first essential for satisfactory results is correct design. Nearly all failures in reinforced concrete are chargeable to lack of experience on the part of the designer rather than to the failure of the workmen to properly carry out the work. The exceptions to this statement are few and far between. Occasionally we run across an exhibition of monumental ignorance on the part of a foreman, who has substituted ordinary ashes for good furnace clinker in cinder concrete, with the natural result that the ashes-cement-mud so formed did not stand up. But granting that the foreman is familiar with the elementary principles governing the selection of suitable concrete materials, and the design is worked out with good judgment, the engineer has the satisfaction of knowing that the work can be executed without the danger and risk incidental to structural steel construction or even that incident to the erection of the ordinary mill building.

FIG. 1. INTERIOR VIEW OF LINDEKE-WARNER BUILDING, ST. PAUL, MINN., SHOWING MUSHROOM COLUMNS AND FLAT-SLAB FLOOR.

Of course such a statement carries weight only as it emanates from one who has had a wide experience in the construction of both types of building. The writer's experience in charge of the design of a number of million dollars worth of structural steelwork for bridges and buildings, together with his experience in responsible charge of the reinforced-concrete construction for an equally large amount of building and bridge work, provides the basis for the statement.

A number of municipalities have formulated such rules and regulations as tend to render the construction of reinforced concrete prohibitive from the standpoint of cost. As a general rule the average city (even some of the first class), in designing ordinances governing the construction of reinforced concrete, secures the services of men who have had little or no practical experience whatever in this class of work. Instead of favoring and encouraging the more conservative and better types of concrete construction, the regulations drawn in this way encourage and favor dangerous or at least less conservative types, and in consequence their avowed object of securing safe construction is not attained. It is to be expected that, when the tax-paying owner wakes up to an appreciation of the large amount he is forced to pay unnecessarily by the lack of knowledge of those who are drawing up these regulations, there will be some very radical changes in this department of municipal government, and some interest taken in determining by test what are and what are not reasonable requirements.

CONTINUITY.—Thus, a regulation which demands that all beams shall be figured as simple beams, and makes no requirement for the safe tying together of the construction, is a radically dangerous one. Where the main slab reinforcement runs in but one direction it is admittedly not allowable to figure ribs as continuous. When however, the slab has a two-way reinforcement then the rib may act as a true continuous beam, and, as the writer would look at it, it is not only permissible but desirable to figure it accordingly.

It may be noted that at least eight-tenths of all accidents in the erection of reinforced concrete have occurred with designs in which a one-way reinforcement was used. Such designs, besides being favored by municipal building ordinances, are fostered by the fact that the majority of works on the subject of reinforced concrete utterly fail to treat multiple-way slab reinforcement in a rational manner. The writer has repeatedly subjected long-span slabs with two-way reinforcement to test loads amounting to several times what their ultimate strength would be if figured by the usual published formulas applicable only to one-way reinforcement.

DEFLECTION LIMITS.—Not a f[ew] building regulations have established the ri[gid] requirement that the maximum deflecti[on] under test shall be the same percent[age] of a slab length of the span as that permitted [of the] for a deep beam. This proves tha[t allowed] sponsible for the regulations were [those re]knowledge of the elementary relation[ship] to unit strain and stiffness. [ing in] depth

From the general theory of flexure [of] beams uniformly loaded (1) with a [simple] load W or (2) with a load W conce[ntrated] center, and similarly for beams res[ted] the ends, we have for strength,

$$W = n \frac{S I}{l c}$$

where $n = 4$, or 8, 12, for the four [different] cases. The requirement of stiffness, i. e., [a] maximum deflection, limits the load by [a] different formula:

$$W = m \frac{E I \Delta}{l^3}$$

where $m = 48$, 76.8, 192 or 384 for the [same] four cases.* By equating these values of W the relation between Δ and S is obtained:

$$\Delta = \frac{n l^2 S}{m c E}.$$

This shows that the maximum deflection for the same unit-stress S varies as $\frac{l^2}{c}$ for beams of the same material, while the coefficients n and m make a further wide variation. Such variations of course make it absurd to limit the permissible deflection to a fixed percent of the span, as has been attempted by some ordinances.

Practical test under common conditions of partial restraint shows that in a span of forty times the thickness or depth of the slab or beam, i. e., $l = 40\,t$ ($t = 2\,c$ approximately) a deflection equal to $l \div 250$ will not materially injure the

*In these formulas l = span; c = distance of outermost fiber from center of gravity; Δ = deflection; S = maximum unit stress, and I = moment of inertia.

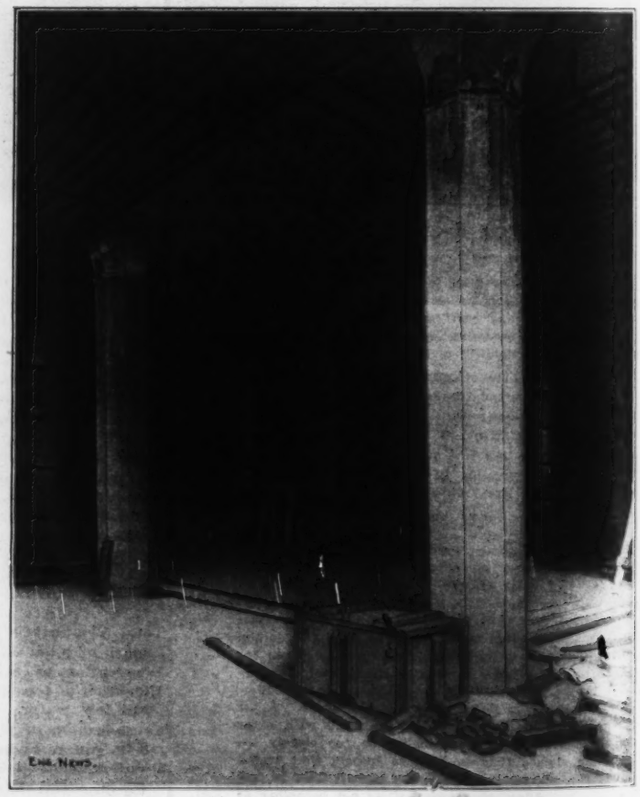


FIG. 2. STOCK HOUSE FOR HAMM BREWING CO., ST. PAUL, MINN.; SOME OF THE 50-TON STOCK TANKS IN PLACE.

*Consulting Engineer, Phoenix Building, Minneapolis, Minn.

construction. Then by the above formula we may deduce that for $l = 10\ t$ the maximum deflection should not exceed $\frac{l}{1000}$. In treating Δ as a percent of the span, our unit of measure is the span, l. Hence the permissible deflection Δ as a percent of l should vary directly as $l \div c$, or in other words directly as the ratio of span to thickness of slab or depth of beam.

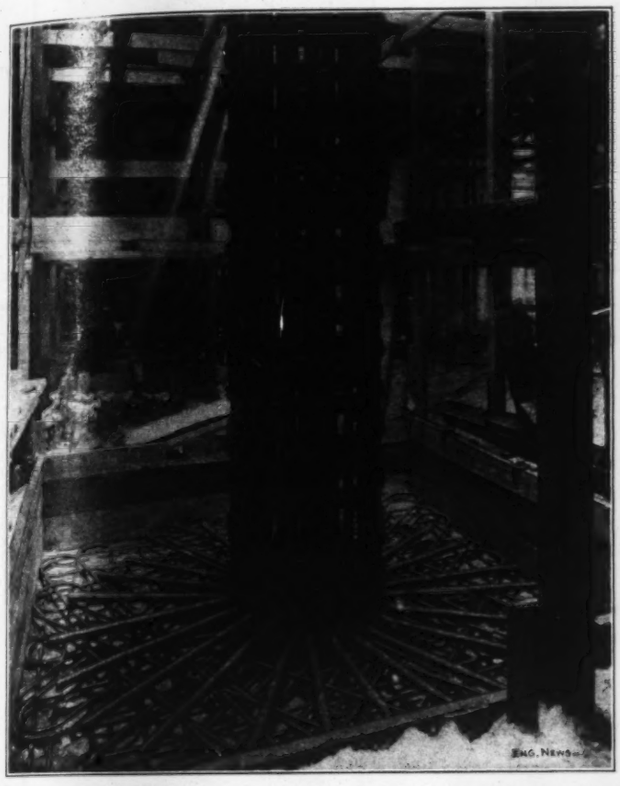


FIG. 3. REINFORCEMENT OF A HEAVY COLUMN AND ITS FOOTING.

STEEL STRESS AND TEST LOAD.—We have also the following regulation, still in vogue in some cities though discarded in others, as follows: The allowed fiber stress on the steel shall be 16,000 lbs. per sq. in. for mild steel, and the test load shall be three times the rated working load. In other words they propose under their theory to strain the steel up to or even beyond the yield-point and expect no permanent set or considerable deflection of the slab under their required test load. This reduces the theory to an amusing absurdity.

LIMITATION OF HEIGHT OF BUILDINGS.—It is almost an everyday occurrence for the constructor to build columns in warehouses for carrying greater working loads than come upon those of a 24-story office-building, and in spite of this there has been agitation to limit the height of concrete construction to four or at most six stories. The absurdity of this can be best appreciated when we consider that the large concrete column may reasonably be expected to be more uniform and give higher results under test than the small—a statement which in view of the Quebec experience, cannot be made as regards steel without some reservation as to the makeup of the section.

SAFETY FACTORS.—In steel construction we have a nominal or imaginary factor of safety of four based on the ratio of the working stress to the ultimate carrying strength in a tensile test. This, however, means an actual factor generally not more than 2 to 2½, since the yield-point value of the metal closely limits the strength of the frame. Compare this with what has been expected of a concrete slab: a load of two times live plus dead load with a limiting deflection of 1/700 the span in a slab spanning 20 ft. or more, with a working load of 200 lbs. per sq. ft., the requirement means a capacity to carry *five times* the working load without injury. Thus in concrete the demand is made for from two to three times the ultimate strength that would be required in structural steel! And still the concrete stays in the field.

CONFLICTING REQUIREMENTS FOR COLUMNS.—As recently as three years ago we could readily find one city which permitted a small allowance for vertical steel in a reinforced-concrete column with no recognition of the value of the hoops and ties in their relation to the ultimate strength, while another city allowed for the hooping without recognizing the efficiency of the vertical steel when combined with the hoops. They are nearly all now revising these obsolete requirements. The writer will venture to say that there is not a practical engineer engaged in reinforced-concrete construction to-day who does not appreciate the advantage of vertical steel combined with hoops in proper proportion.

MULTIPLE-WAY REINFORCEMENT. — One of the practical advantages of multiple-way reinforcement lies in the fact that it is almost free from the danger of sudden collapse. Such a slab will act at first somewhat like a flat dome and slab combined, but as the deflection gradually increases it will gradually commence to act as a suspension system in which the concrete will merely hold the rods together and distribute the load over them. For example, a slab 24 ft. square and 6 ins. thick can readily be loaded so that the deflection would be 8 or 10 ins. It would crack clear through the concrete and would still carry the load that caused this large deflection and require a large additional load to ultimately break the slab down.

The reason that this type has not come into favor more rapidly is in large measure due, as already pointed out, to the improper rules adopted in municipal regulations. Take for example a flat slab supported on four sides and one supported on two sides; the average building ordinance treats the bending moment as though it were equal in the two cases, while as a matter of fact the moment of the external load is 50% greater in the latter. To make this point clear we may put the proposition in terms of the work done by the construction in carrying the load to its support. In the case of the slab supported on two sides the construction has to carry the half total load carried by each support through an equivalent distance of one-fourth the span. In the case of the slab supported on four sides the center of gravity of the load carried by each support is only one-sixth of the span distance from the support, and hence the work done is only two-thirds as great as in the other case.

QUALITY OF STEEL.—It is frequently urged against reinforced concrete that we do not know positively the quality of material which we are using. As a matter of fact the standard brands of Portland cement on the market to-day are far more uniform in quality than the ordinary merchant steel and it is not as a rule to the cement which enters into our building that we need pay as much attention as to the quality of the reinforcing metal. Some manufacturers of steel have considered, apparently, that anything was good enough for reinforced-concrete work. Bars that are hard and so brittle that they would snap short have been sold to the uninitiated as suitable material for reinforced-concrete work, and not a few building departments have been hoodwinked into allowing 25% or 30% more for so-called hard steel rolled from miscellaneous scrap, old rails and other low grade material, which has frequently proved so brittle as hardly to bear the slightest rough usage in handling. It is unfortunate indeed that such material should be trusted to withstand a higher working stress than good tough metal, the characteristics of which we know with certainty.

As the writer looks at it, the concrete can reasonably be expected to work with the metal only through a moderate range of stress, such as good medium steel can safely be trusted to carry. Bearing in mind the fact that the modulus

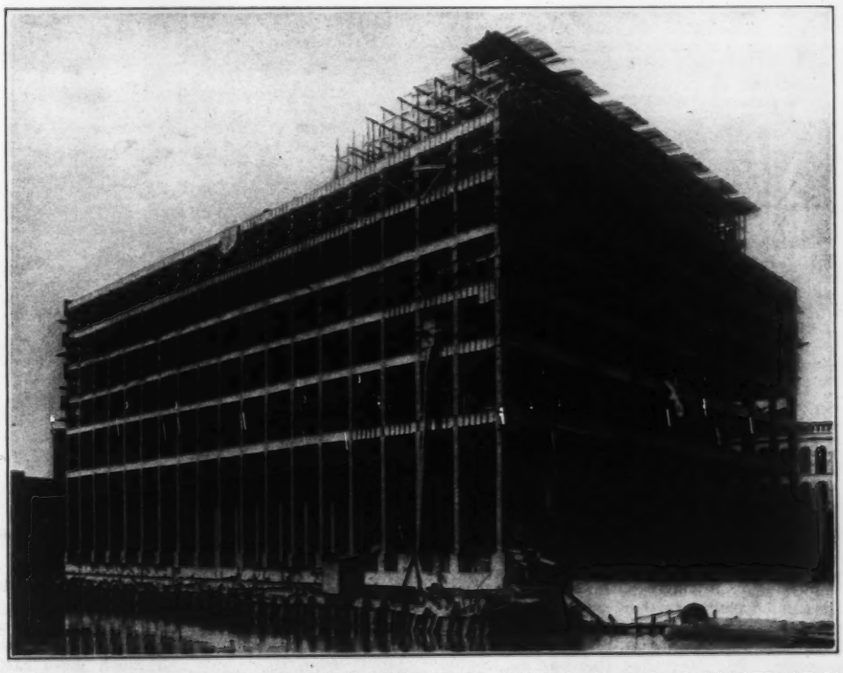


FIG. 4. EXTERIOR OF BOSTWICK-BRAUN WAREHOUSE, TOLEDO, O., DURING CONSTRUCTION.

of elasticity of the mild and the high steel is practically the same, the advantage of the latter is open to serious question. In fact the writer prefers a material which he can test practically to the yield-point and feel assured that it will not let go quickly but give him ample warning in case of overstrain under test or in use.

A paper by Capt. Sewell, presented to the American Society of Civil Engineers three years ago, contained the remarkable statement that a reinforced-concrete floor could not be economical without concrete ribs or steel beams. Since that time the writer has been associated in the erection of over 400 acres of floor built without ribs or beams, scattered from Portland, Me., to Portland, Ore., in the United States, and from Regina, Sask., in the north to Melbourne, Australia, in the south. This work has been erected, without an accident to the construction, in temperatures from 24° below zero to 102° in the shade.

Recognizing the general principles outlined the writer has in his practice adopted a multiple-way reinforcement in all his work. After finding that long-span slabs were much more economical in general than ordinary short-span slabs, and after building 20-ft. and 24-ft. panels, etc., he naturally began to question whether it was worth while to put in any ribs at all and developed (and patented) a system of flat slab construction known as the "Mushroom System" which has been applied to buildings of all kinds and heights up to twelve stories, without a single case of collapse or accident chargeable to the risk of concrete construction.

The advantage of this type is as follows. For a given clear story height it effects an economy of about 10% of the material in the vertical walls. It simplifies the centering and greatly reduces the cost. It presents a remarkable degree of stiffness due to the fact that any concentrated load brings into action the reinforcement of the whole panel and hence it is probably more nearly free from vibration under heavy machinery than any other type of construction in use to-day. With no ribs projecting below the ceiling there is a much better distribution of light throughout the building. It enables the placing of shafting to better advantage in factory buildings than is practicable with the rib construction. Where, owing to the nature of the goods to be stored, a sprinkler system is desirable it effects a considerable economy since

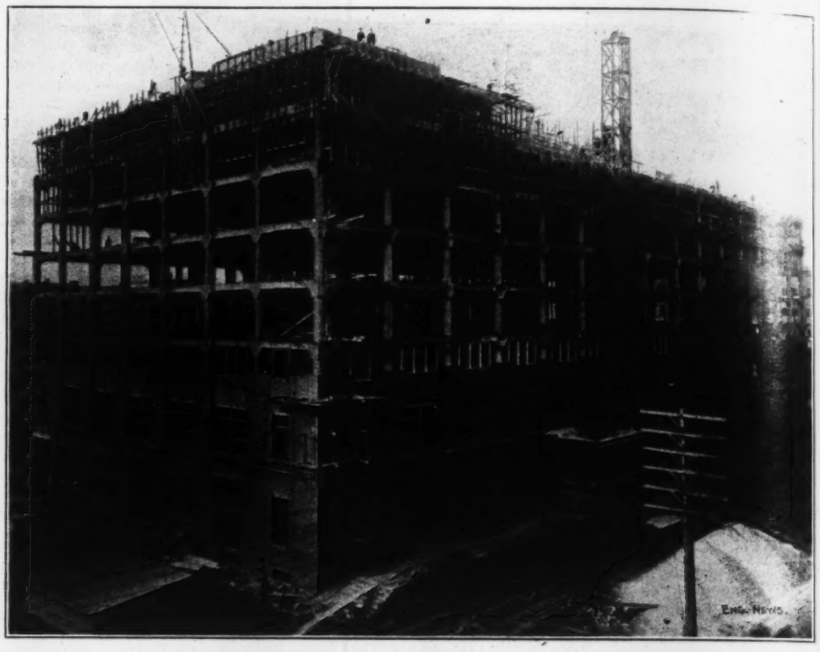


FIG. 6. EXTERIOR OF BUILDING FOR JOHN DEERE PLOW CO., OMAHA, NEB.

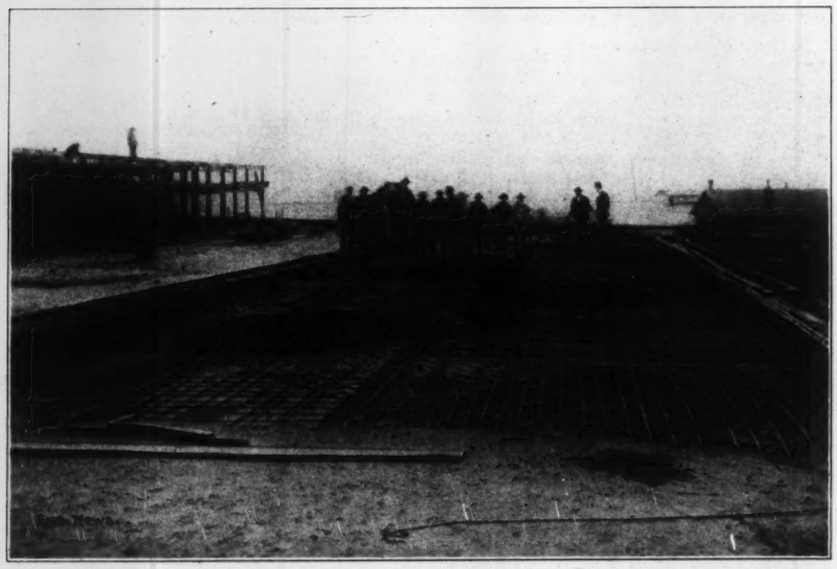


FIG. 5. FLOOR REINFORCEMENT, BOSTWICK-BRAUN WAREHOUSE; TRACKS IN PLACE FOR POURING THE SLAB CONCRETE.

with no ribs to interfere with the sprinkler the heads can be placed farther apart. In eliminating the ribs and enabling the use of a flat form for centering much greater rapidity of erection is possible. The fact that the load is carried directly to the support instead of around a corner as where beams are used effects a considerable economy in materials, as does also the fact that the concrete is being worked by the multiple-way reinforcement in several directions and the distortion in one direction is in a measure offset and counterbalanced by the strain in the other direction. The flat slab type eliminates many practical disadvantages of the beam system, such as the bother of stirrups and the usual difficulty attending splicing the beams. In a construction using beams it is hard to make a good splice with a wet concrete since the concrete will naturally tend to flow off in an inclined plane bringing to the surface the inert material known as laitance which will prevent the bonding of the new material to the old unless the surface is broken up before proceeding with the work. In the mushroom system, owing to the fact that the concrete does not have so great a head under which to flow, there is little trouble from this score and much more satisfactory execution of the work is practicable with ordinary care. Also, since the reinf[illegible]ent runs in so many directions over the sup[illegible] it serves to tie the construction in such a m[illegible] that a sudden collapse is impossible after [illegible] material has been given even a day's time [illegible] drying weather to set up.

As to economy, the amount of mat[illegible] required to build a slab or panel that will carry a given test load is less than with any other type that the writer has seen or has himself been able to devise. This economy increases rapidly as the working load to be carried increases, since the strength of the slab increases approximately with the square of the depth and hence the relative increase in cost for a given increase in the capacity of the construction is small.

SOME ILLUSTRATIVE BUILDINGS.—The following describes briefly a few typical buildings constructed on this system, and notes the special points of interest of each.

EXAMPLE 1.—Lindeke-Warner Building, St. Paul, is 165 by 235 ft. Louis Lockwood was the architect and Butler Brothers the builders. Exterior walls are bearing walls of brick; lintels over windows consist of a concrete girder going clear around the building. Fig. 1 shows an interior view, the maple floor surfacing just being laid.

Sheet-metal forms were used throughout, and corrugated steel sheets were used in place of boards for planking. The contractors succeeded in erecting walls, floors and columns (placing strips and strip fill for the finished floors as they went along) at the rate of a story about every ten days of good working weather.

In the design of the concrete work the writer was governed in the spacing of the columns not by economic considerations but by the arrangement worked out, which was claimed to be more convenient than a longer and more economic spacing would have been.

EXAMPLE 2.—A stock house for the Hamm Brewing Co., of St. Paul, has a maximum panel 26 ft. by 22 ft. 10 ins., designed to carry a working load of four stock tanks, having a weight of over 50 tons apiece. The slab is 14 ins. thick at the thinnest place. It is reinforced with 25 ⅝-in. rounds each way. Fig. 2 is a view in this building after some of the tanks had already been placed.

The construction of this building was started in the middle of a Minnesota winter and carried through without regard to temperature, concrete being placed at times when it was as cold

as 24° below zero; good results were secured by proper heating of materials and using a small amount of salt.

The centering for this work was timber. The columns are octagonal, the heads being formed with cast-iron molds. It may be noted that the largest column in this building is a 30-in. octagon, designed to carry a working load of 1,050 tons, the column being about 25 ft. high. These figures should interest those who desire to limit the height of reinforced concrete to the very low buildings since the average 20-story office-building rarely requires columns carrying greater loads.

EXAMPLE 3.—The Bostwick-Braun Bldg., Toledo, Ohio, is illustrated by Figs. 4 and 5. Mr. George S. Mills was the architect, the writer designing the reinforced-concrete work for the contractors, A. Bentley & Sons. The building is 220 ft. square on the street fronts but cut off in trapezoidal form by the water front, view of which we illustrate. The construction of the sea wall and the foundations presented some little difficulty, but after the centering was practically out of the mud the balance of the work was erected at the rate of a story every seven or eight days of good working weather. This record it would be hard to find equaled in steel or timber construction in buildings of equal magnitude, but it has been duplicated with the mushroom system by numerous contractors, in fact on nearly every building of this size, though working the usual day shift only.

FIG. 7. INTERIOR OF A FLOOR IN THE JOHN DEERE BUILDING.

Wood centering was used throughout this building. The columns are octagonal and a standard adjustable cast-iron form was used to shape the heads.

A test load on one bay of the floor of the Bostwick-Braun warehouse consisted of nails in kegs, seven to eight tiers deep, supplemented by pig lead and solder in boxes, making a total load equivalent to 1,000 lbs. per sq. ft. over the full area of the panel.

Fig. 5 shows the reinforcement of one floor, with track laid for casting the concrete.

EXAMPLE 4.—A building erected in Omaha for the John Deere Plow Co., is 135 by 284 ft., eight stories in height. O. A. Eckerman was the architect, Lawrie & Fisher consulting architects, and Prof. A. N. Talbot consulting engineer for the owner, while the writer designed the reinforced-concrete work for the contractors, the Leonard Construction Co., of Chicago. The concrete work of this building was erected at the rate of one story per week of fair weather with the exception of one or two delays due to the failure of the material men to deliver the needed amount of crushed stone to carry on the work continuously. The crushed rock, sand and cement were delivered on tracks in front of the building and unloaded by means of a jib crane into the hopper and carried by gravity to the mixer and then the concrete elevated by a hoist, which may be plainly seen in Fig. 6.

Sheet metal forms were used for the columns; all the external columns are circular in form. The timber centering was made largely of 1 × 6-in boards cleated in panels of three to four boards in width so that they could be handled with little nailing to the joist. The joists were 2 × 6-in., about 18 ins. on centers, with 2 × 6-in. studs.

In designing the columns, the writer prefers to make the ratio of the vertical steel to the amount of the hooping from 0.7 for heavy columns to 1.0 or more for the lighter columns. These ratios seem to give the most satisfactory results in his practice. In columns of various buildings in Minneapolis, St. Paul and Milwaukee he has used the following working stresses: 1,000 lbs. per sq. in. on the core area of the concrete (1:2:4), 16,000 lbs. per sq. in. on 2.4 times the volume of the hoops, as imaginary verticals, and 12,000 lbs. per sq. in. on the vertical steel. In the John Deere building, however, a richer mixture was used for the columns and the stresses were somewhat reduced. For the core area of the column a compression of 800 lbs. per sq. in. was used, and a somewhat smaller value than customary was taken for the hooping, based by Prof. Talbot upon tests which were made upon columns in which the above ratios of the amount of the vertical steel to the hooping do not appear to have been followed.

THE COST OF CONSTRUCTION.—Earlier in this article it has already been stated that the economy in cost is one reason for the rapid advances in favor of reinforced-concrete construction for buildings. An economically designed reinforced-concrete building costs less than first-class timber mill-construction for warehouse purposes, while for an office-building the saving may readily run from 30% to 60% of the cost of the usual steel skeleton, and we have in the resulting structure a building protected from corrosion in the most perfect manner known.

FINISH AND ORNAMENTATION.—From the artistic standpoint the engineer and architect are gradually beginning to recognize the characteristics of the material and the methods by which a pleasing exterior surface may be obtained at a small cost.

In the Smythe Block, of Wichita, Kan. (Louis Curtis, of Kansas City, architect), the exterior walls as well as the skeleton and floors are of reinforced concrete. The ornamentation in this case consists of terra-cotta inlaid in the work. The surfaces as left by the boards were given a rough stipple coat. This expedient has also been used to advantage in bridge construction, the rough body of the structure making a very pleasing contrast with the highly ornamental manufactured stone railing. This finish was adopted by the writer for a bridge over the Red River of the North at Fergus Falls, and for a bridge of the mushroom type with independent ribs over a ravine on the Mississippi River Boulevard between Minneapolis and St. Paul. This structure has a length of 227 ft. and a height of 95 ft. from the roadway to the bottom of the ravine. The manufactured stone railing is almost white in color, while the stipple work in the structure is the bluish cement gray, making a very pleasing contrast.

Numerous efforts have been made to secure a smooth concrete surface by treatment of the forms. In the Grand Ave. Viaduct in Milwaukee a plaster coat of lime and plaster of paris on metal lath was called for on the interior of the forms, the plaster form to be oiled in advance of pouring the concrete and the specification required that there should be no blemish in the finished surfaces. The specification was impossible to fulfil, as was clearly proven in the execution of the work; notwithstanding the greatest amount of care on the part of the contractor, at every point where new concrete was placed upon old the line of demarkation of the layers was plainly visible in the finish. This difficulty is readily overcome at an insignificant cost by the method of treatment previously outlined and the extreme degree of care in makeup of forms is obviated while the general effect seems to the writer more pleasing.

Steam Curing of Concrete Blocks.*

By F. S. PHIPPS.†

A block cured with steam vapor is harder and stronger at the expiration of 24 to 30 hours than a block cured by the old way of sprinkling or spraying at the end of 7 to 10 days. The method of manufacture is as follows: The blocks are made in ordinary machines and transferred into the ovens where there is no sun or current of air to cause them to dry before they start to set. As soon as an oven is filled it is closed and within one to two hours the steam is turned on and it immediately condenses upon the block the same as dew on grass, and in less time than it is possible to spray a block, it is filled with moisture. In this way a block can be given so much moisture that it will become mushy and mash before the cement sets. This fully refutes the argument that steam curing dries the blocks before they have the proper amount of water.

If a block produced in 24 hours is equally as good or better than a block made in 7 days under the sprinkling system, is this point not worth considering in installing a steam-curing plant? Further, blocks can be delivered upon a contract within 48 hours after starting the plant, doing away with the one great objection the buyer has against concrete blocks—that of being compelled to wait several days for them after placing the order. A denser block can be produced as the steam does not wash any of the cement from the block, as is the case with the sprinkling system. Also the color of the blocks is more uniform, regardless of the cement used. We have made blocks using dark, as well as light cement, and find them to be almost the same color; the steam gives them a lighter color than it has been possible to obtain before. With steam curing, blocks can be made all winter, which gives the same opportunity to build with blocks as with brick. Again, in the case of rush orders, delivery can be made in 36 hours, or just as quick as stone can be obtained. It has been our experience that by steam curing, a better block is produced, both in color and strength, and a block that is much more salable than the old water-cured block.

COST OF MANUFACTURE OF CURED BLOCKS.—The plant of the Central Stone Co. is using Kaw River sand, which is sharp and clean and costs delivered, including shrinkage and waste, $1.10 per cu. yd. The price of cement at the present time is $1.25 per bbl. The proportions range from 1:3 and 1:5 and the cost for the 1:5 mix. is 3 cts. per exposed sq. ft. and for 1:3 is 5 cts. per ft. With one man to take care of the boiler, ovens, engine and the mixing of the materials, at $2 per day and two men to run the machines at $1.75 per day, we turn out 560 ft. of rock. Allowing 50 cts. for coal per day and $1 for office help, the blocks cost us for labor, very close to 1¼ cts. per ft. with the 3 cts. added for material in the 1:5 blocks, the cost will be 4¼ cts. per ft. and of the 1:3 block, 6¼ cts. per ft. These figures do not allow for insurance, wear and tear on machinery or the

*From a paper presented at the annual meeting of the National Association of Cement Users, Cleveland, O., Jan. 11-16, 1909.

†Manager, Central Stone Company, St. Joseph, Mo.

manager's salary. If three men were used on the machines, instead of two, the cost would be no greater for mixing or for curing than it does for two men. As near as we have been able to ascertain, 1,000 to 2,000 lbs. of coal will cure three ovens of blocks, each oven containing from 140 to 160 blocks. Our men on machines are able to turn out 140 blocks 32 ins. long by 9 ins. high, giving two sq. ft. to the block. The blocks we make for building purposes are 4-in. L-shaped blocks, ranging from 4 to 32 ins. To build a wall from 8 to 12

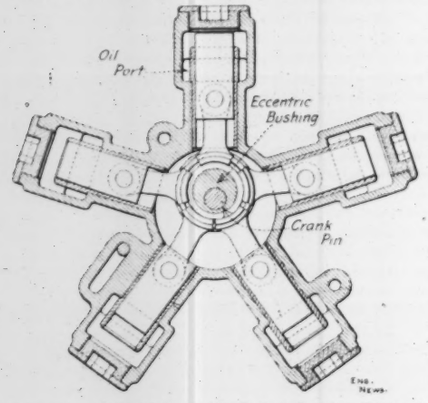


Fig. 1. The Manly Hydraulic Drive: Section Through Pump Cylinders.

ins. in thickness, we use two 4-in. blocks, so cost of same must be figured on a 1:3 proportion for outside wall at a cost of 6¼ cts. per ft. and 1:5 proportion for inside wall at a cost of 4¼ cts. per ft., making a total cost of a 12-in. wall, 10½ cts. per ft. The hollow block we make is somewhat cheaper, as it is only 9 ins. high and 8 ins. wide. We make all sizes, but this is the most used. It costs about one-third less for material and about the same for labor.

PLANT.—The cost of a plant will depend on the size and equipment desired. We have a 25-HP. boiler, which cost with all piping and fitting, $225 and makes steam for 6 to 9 ovens. The ovens cost about $50 each. Almost any old boiler will answer, and the oven can be made of sheet iron, although this class of oven is not to be recommended.

A Hydraulic Variable Speed Transmission.

There are on the market at the present day a number of variable speed transmissions which allow a continuous gradual variation throughout a moderate range of speed. Such transmissions are used in machine shops, canning factories, paper mills and in connection with numerous other manufacturing processes. Practically all of the transmissions in common use which will give any desired speed ratio within their range (as distinguished from those giving a limited number of fixed ratios) depend upon frictional contact for transmitting the power.

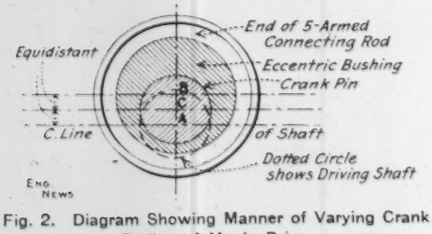


Fig. 2. Diagram Showing Manner of Varying Crank Radius of Manly Drive.

(To change the effective radius, center of bushing, B, is revolved about center of crank pin C. At the same time, C revolves about center of shaft, A, an equal amount in the opposite direction, keeping the effective crank pin center, B, always on the same diameter of the shaft.)

A hydraulic transmission, known as the Manly Drive, has recently been brought to a practical working stage of development by its inventor, Mr. Charles M. Manly, and appears to possess decided advantages over the frictional types.

In the Manly Drive, a pump connected to the source of power pumps oil through a pipe to a hydraulic motor, or engine, connected to the shaft where the power is to be utilized. Since the oil is practically incompressible and does not expand upon decrease of pressure, it is evident that this will give a positive drive. That is, the displacement of the motor piston must correspond exactly to that of the pump piston. If pump and motor have the same cylinder diameter and length of stroke, the driving and driven shafts revolve at the same speed. If the stroke of the pump is reduced by one-half while that of the motor remains as before, the driven shaft will revolve at one-half the speed of the pump shaft because it will now take two pump strokes to displace a volume of oil corresponding to one motor stroke.

The pump and motor are almost exactly similar in construction. In order to give a sufficiently uniform torque, they have each five cylinders placed radially about the shaft. The single-acting, trunk pistons of these five cylinders act upon a common crank pin, as shown in Fig. 1, the construction in this respect being not unlike that of the gasoline engine described in Engineering News, Sept. 10, 1908, p. 275. In the present case, however, the cylinders are stationary while the shaft revolves. The pistons are ground to fit and are without piston rings or packing of any sort.

The variation of speed is effected by changing the throw of the crank on the pump, while the stroke of the motor pistons is kept constant. The effective crank radius can be varied continuously from its maximum length to zero, so that any desired speed ratio is obtainable. With the crank arm reduced to zero, the crank pin revolves concentrically with the shaft, and the pistons are stationary. In this position the transmission acts as its own brake and the driven shaft is locked stationary. The change of effective crank radius is made by means of the eccentric bushing on the crank pin shown in Fig. 2.

The mechanism used for changing the crank radius is not acted upon directly by the hand control lever, but this lever controls the pilot valve of a piston driven by oil from the main pressure line. The motion of this piston is utilized to produce the radial movement of the crank pin. The piston-valves controlling the distribution of oil in the five pump cylinders are driven from a common eccentric on the shaft. This eccentric is set 90° ahead of the crank for forward motion, and the crank pin is moved across, in changing speeds, along a straight line relative to the shaft, so that the crank arm and eccentric arm remain always at right angles. When the crank pin passes beyond the central position, the eccentric is 90° behind instead of ahead, and the reverse is obtained. The range of speeds in the reverse direction is the same as in the forward direction, and all changes of speed, reverse and brake are controlled by one and the same hand lever.

The arrangement of valves and oil passages is shown diagrammatically in Fig. 3. On account of the incompressibility of the working fluid, the valves have no lap nor lead. With the valve in mid-position and the pump (or motor) piston at the end of its stroke, the speed of the valve is at a maximum while the pump piston is, for the instant, at rest. Cut-off and release are therefore simultaneous, and the action is smooth running and without knocks. All five valve chests are connected by cross passages as indicated in the figure. The passages connecting valve chests of pump with those of motor may be of any reasonable length, and there is no restriction on the relative positions or angle of driving and driven shafts. One of these passages carries high pressure oil from pump to motor and the other returns the oil at low pressure from motor to pump, but when the driven shaft is reversed, as pr... plained, supply and return pipes in... that both must be able to withstan... mum pressure.

Since the speed ratio of driven ... shaft can be reduced to as near zero ... the torque that can be exerted by ... shaft is limited only by the maximu... pressure in the oil pipes and cylinde... transmissions already built, this maxi... sure is 2,000 lbs. per sq. in., and a ... is provided which opens at this pr... allows oil to by-pass from the hi... pipe to the low-pressure reservoir ... plies the pump and into which the ... hausts. The opening of the relief ... not, it is claimed, materially reduce ... below that due to a pressure of ... per sq. in. A pressure of from ... 15 lbs. per sq. in. is maintained ... reservoir to prevent cavitation. As ... of the driven shaft is reduced, full ... be transmitted—neglecting losses due ... tion, etc.—down to the point where the ... reaches the 2,000-lb. limit for which ... valve is set. Further reduction of ... panied by reduction of power ... because the torque that can be exer... the driven shaft remains constant at ... a pressure on the motor pistons of 2,000 lbs. per sq. in.

An extensive series of tests has been ... one of these transmissions by Mr. Geo. H. Barra... at the factory of the Manly Drive Co. in Brook...

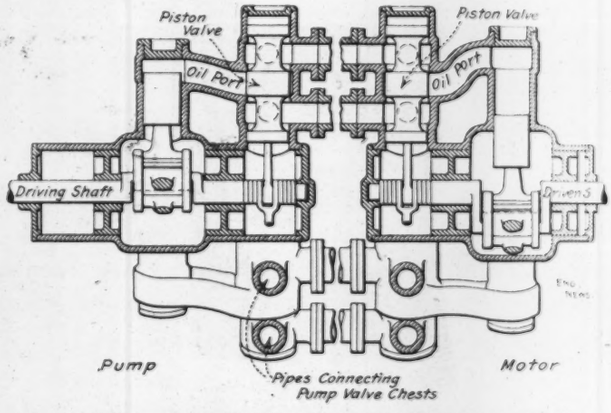


FIG. 3. DIAGRAMMATIC SECTION OF MANLY DRIVE, SHOWING ARRANGEMENT OF VALVES.

lyn, N. Y. Complete records of the tests made show a mechanical efficiency of from 85% to 90% within a reasonably wide range of speed variation. It is stated that in the course of a test which lasted eleven hours, during which the transmission was in continuous operation under load, the temperature of the circulating oil rose to only 145° F. This temperature was read from a thermometer in a cup screwed into the high-pressure oil pipe. The circulating oil is ordinary mineral, machine oil, which has a viscosity about six times that of water at this temperature.

In making the tests for efficiency, power was obtained from a 15-HP. electric motor of which the efficiency at various loads was first determined so that the power supplied to the transmission could be calculated from the voltmeter and ammeter readings. The power output of the transmission was measured by a prony brake. One series of tests was made with constant power delivery at various speeds, and another with constant load on the brake (constant torque) and various speeds. In both cases the speed was varied by means of the transmission, the speed of the driving shaft being kept the same. A mechanical efficiency of above 85% is shown throughout a considerable range of speed for both these conditions.

In Tables I. and II. are given the results of tests made with the circulating oil at maximum temperature. These tests show a slightly higher

efficiency than those at medium temperature. It should be remembered that the maximum power transmitted in the tests was limited by the size of the electric motor to 57% of the rated capacity of the drive.

The transmission tested was designed for 24 HP. at [illegible] r. p. m. of the driving shaft and two motors, weighed complete about 1,000 lbs.

The Manly Drive Co. (17 Battery Place, New York City) have had a truck equipped with one of their transmissions in continual operation for 22 months. During this time it has been always loaded to a gross weight of 8,500 lbs., which was exceeded at times by the addition of a useful

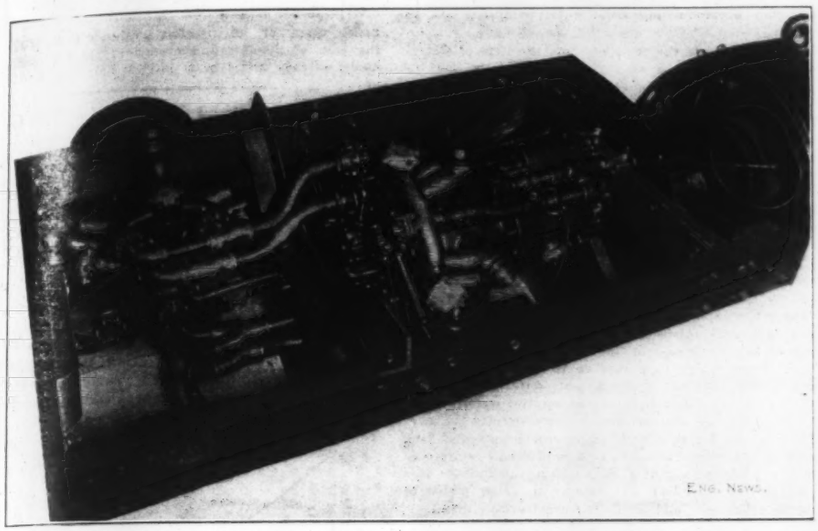


FIG. 4. MANLY DRIVE FOR 5-TON AUTOMOBILE TRUCK, MOUNTED ON TESTING FRAME.
(The hydraulic control cylinder is shown at the right. One of the two Manly motors has been removed for the test.)

was intended for a 5-ton automobile truck. The pump has cylinders of about 2½ ins. diameter and 1½-in. maximum stroke. Two separate motors were provided, one for each rear wheel of the truck, but on account of the difficulty of keeping the load alike on the two prony brakes the test was made with only one motor in operation, the other being entirely disconnected. It should be noted that the Manly Drive as applied to automobiles acts also as a differential gear, and it is this feature which made it impracticable to test it with both motors in operation. During the tests, the drive was mounted on a wooden frame, as shown in Fig. 4, in the position it would occupy on the truck.

The motor cylinders are of the same diameter as those of the pump, but the stroke is fixed at 3 ins., giving a speed reduction of two to one at full pump stroke—or four to one with both motors in use, as they would be in driving the truck. The drive tested, with pump and load to the permanent test load of gravel. It is claimed that no repairs have been required and that, when a careful measurement of the pistons and cylinders was recently made with a micrometer gage reading to .0001 of an inch, it was impossible to detect any wear or change from the original diameters which had been previously recorded. In fact, it is said that the marks of the finishing tool were still discernible. This immunity from wear is ascribed to the thorough lubrication afforded by the high pressure oil. The hydraulic drive on this truck gives a great flexibility of control which is of value in crowded city streets. The convenience of the reverse is especially noticeable as compared with change-gear transmissions, for it is possible to change instantly, or as quickly as is desired, from forward to backward motion.

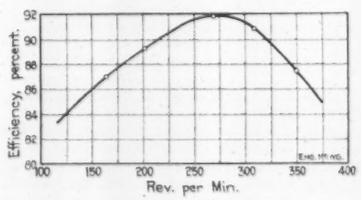


Fig. 5. Efficiency Curve of Manly Drive; Constant Power.
(Plotted from Table I.)

TABLE I.—DATA AND RESULTS OF EFFICIENCY TESTS OF MANLY DRIVE.

Temperature of circulating oil.....Maximum temperature.
General conditions.....Constant power, driving shaft. Constant speed, driving shaft. Varying speed, driven shaft. Constant power, driven shaft. Varying weight on brake-arm.
Date of test.....Dec. 9, 1908.

1. Amperes	55	55	55	55	55
2. Volts	230	236	239	238	237
3. Watts (Line 1 × Line 2)	12,650	12,980	13,145	13,090	13,035
4. E. HP. of current (Line 3 ÷ 746)	16.96	17.4	17.62	17.55	17.47
5. Efficiency of elec. motor, taken from calibration curve, per cent	84.3	84.4	84.4	84.4	84.4
6. HP. supplied to driving shaft (Line 4 × Line 5)	14.3	14.68	14.87	14.81	14.74
7. Rev. per min., driving shaft (elec. motor)	750	755	760	760	755
8. Rev. per min., driven shaft (Manly Hyd. motor)	350	310	270	202	163
9. Temperature of oil in circulation, Fahrenheit	132	133	134	135	135
10. Net weight on brake-arm, lbs.	47	56.5	66.5	86	103.5
11. E. HP., or power delivered to driven shaft	12.50	13.33	13.66	13.23	12.83
12. Effic. of Manly drive (Line 11 ÷ Line 6), per cent	87.4	90.8	91.9	89.3	87

TABLE II.—DATA AND RESULTS OF EFFICIENCY TESTS OF MANLY DRIVE.

Temperature of circulating oil.....Maximum temperature.
General conditions.....Varying power, driving shaft. Constant speed, driving shaft. Varying speed, driven shaft. Varying power, driven shaft. Constant weight on brake-arm.
Date of test.....Dec. 9, 1908.

1. Amperes	55	49	39.5	32.5	25.5	20.2
2. Volts	230	228	226	236	236	238
3. Watts (Line 1 × Line 2)	12,650	11,172	8,927	7,670	6,018	4,808
4. E. HP. of current (Line 3 ÷ 746)	16.96	14.98	11.97	10.28	8.07	6.44
5. Efficiency of electric motor, taken from calibration curve, per cent	84.3	83.4	80.5	78.4	74.8	71.5
6. HP. supplied to driving shaft (Line 4 × Line 5)	14.3	12.46	9.63	8.06	6.04	4.60
7. Rev. per min., driving shaft (elec. motor)	750	745	740	735	735	760
8. Rev. per min., driven shaft (Manly Hyd. motor)	350	315	245	200	145	105
9. Temperature of oil in circulation, Fahrenheit	134	136	137	137	136	136
10. Net weight on brake-arm, lbs.	47	47	47	47	47	47
11. E. HP., or power delivered to driven shaft	12.50	11.26	8.76	7.14	5.19	3.76
12. Effic. of Manly Drive (Line 11 ÷ Line 6), per cent.	87.4	90.2	90.9	88.6	85.9	81.6

The Applicability and Comparative Cost of Concrete and Reinforced Concrete for Subway Construction.*

By CHAS. M. MILLS.†

Concrete has been used in building metropolitan underground railways from the beginning of such construction. It was used in the construction of the Metropolitan District Ry. in London, authorized by Act of Parliament in 1854, construction beginning in 1860, the successive extensions not being completed until 1884. It was used in backing the haunches of the brick arches, in the footings of masonry side walls, in backing behind the side walls as the timbering was removed, and later in the side walls themselves and in the inverts.

The advantages of concrete have evidently influenced the designs of all the underground railways to the present time. In the earlier construction stone masonry and brick work predominated, but these have yielded to concrete as its properties and adaptability to meet varied requirements became better understood, its use receiving an impetus by the production of Portland cement. With the addition of reinforcement, concrete has increased its claim upon designers and constructors, so that to-day it is indispensable, the combination possessing properties and affording facilities possible with no other material. It may be noted that in the railway subways in European cities, concrete has been used mostly without reinforcement, contrary to what might have been expected, while in America, in many cases, reinforcement has been liberally utilized.

The adaptability and advantages of concrete both plain and reinforced to subways is so complete in most respects and is so well understood, that only the salient features will be noticed, with general reference to economies.

To attempt satisfactorily to show by figures the savings effected by the use of concrete either plain or reinforced in subway construction, involves the consideration of many conditions to avoid producing misleading impressions. The extent of the permissible interference with street traffic, the nature and density of the traffic, the local costs of the materials and the facilities for their storage and handling, the conveniences for handling the excavated material, as well as many other details, all affect the cost. In view of these considerations, no definite figures will be given. It has been a surprise to the writer, that the aggregates of items of cost in different designs for subway structures carefully developed with view to economy, have varied so little, the difference being small percentages of the entire cost involved.

It is well understood that concrete may be made with ordinary labor under efficient direction, so that its unit

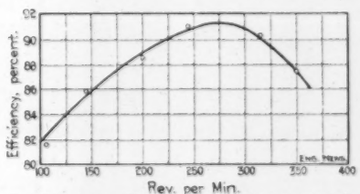


Fig. 6. Efficiency Curve of Manly Drive; Constant Torque.
(Plotted from Table II.)

cost compared with that of brick work is usually much cheaper, especially under the conditions which prevail in underground construction in busy city streets, and concrete as compared with brick work for this kind of construction is so superior, that the use of brick work is now limited to collateral details, such as sewer work, underpinning and miscellaneous work at passenger stations.

For sidewalks sustaining earth pressure as well as vertical loads, reinforced concrete is especially advantageous, since the thickness may be made but a fraction of that required for walls of brick or stone masonry. Thin side walls reduce the width of the trench to be excavated, an important and costly item of work in city

*Paper read at the Annual Meeting of the National Association of Cement Users, Cleveland, O., Jan. 11-16, 1909.

†Principal Assistant Engineer, Philadelphia Rapid Transit Co.

streets and are usually necessary, since the available space under the beds of streets is frequently limited, either by existing structures, or by the necessary reservations for sewers or other underground structures, as municipal requirements increase.

Thin walls also may be built with vertical I-beams to resist the earth pressure with vertical jack arches of concrete between them. The cost of such walls is slightly more than for those of reinforced concrete, comparison of cost including many details. The I-beams are usually 12 or 15 ins. deep and spaced 5 to 6½ ft. apart on centers, and require same thickness of concrete back of them to cover the outer flanges. In addition, protection of the beams from corrosion and the fact that the wall is pierced every 5 or 6 ft. by the beams renders waterproofing necessary. The placing of waterproofing from the interior of the trench requires a thin wall of brick or concrete outside of the beams. The total thickness of such composite walls, without concrete covering over the inner flanges of the beams is usually from 21 to 24 ins. The inner flanges of the beams being uncovered require painting, which entails a maintenance charge. If the inner flanges of the beams are covered with concrete, the total thickness of the wall is increased, and this together with the details requisite efficiently to secure the concrete to the flanges, are additional items of expense.

Little advantage, if any, in supporting traffic during construction is afforded by the beams, unless steel roof beams are used, since the timbering required prior to the erection of the beams may readily be designed to fulfill this purpose.

The side walls of reinforced concrete considered in the comparison of cost are taken 24 ins. thick, though 16 ins. would usually suffice to sustain all the stresses, the additional 8 ins. or 50% being placed for practical considerations, partly construction details and partly to diminish liability of leakage. As the thickness of the wall is increased for the reasons stated, the quantity of main reinforcement is diminished with the resulting saving. No waterproofing is considered in the reinforced-concrete side walls, since with longitudinal reinforcement properly proportioned and distributed in the walls, and with the cement and concrete aggregates properly proportioned, made to a wet consistency and well placed in the forms, the use of waterproofing in reinforced-concrete side walls is unnecessary under all heads of ground water liable to exist in ordinary subway construction, thus eliminating many troublesome details and simplifying the work.

An advantage of reinforced-concrete side walls with longitudinal reinforcement is that no expansion joints are required, and long stretches of wall may be built without cracks due to changes of temperature, or to shrinkage, or to be more exact with such multiplicity of distributed minute cracks that they are harmless, and invisible except under the closest scrutiny. The longitudinal reinforcement may be varied to meet the various conditions, and to produce lesser or greater capacity to resist leakage as desired.

The simplicity and superior water-tightness of well designed reinforced-concrete side walls make them worth more than walls of beams and concrete jack arches even though local conditions might show a slight saving in first cost for the latter. It is possible that in most cases the first cost of reinforced-concrete side walls will be a little less than that for the other type, but the difference will be a small percentage of the whole cost.

In the use of reinforced concrete for subways, both for side walls and roofs, plates of uniform thickness have generally been employed instead of an alteration of beams and slabs.

The refinement of workmanship required in placing concentrated reinforcement in beams, with shear rods, and the other details of beam and slab construction is injudicious from practical considerations in underground work. Such work is usually done in restricted space and with artificial light, so that good workmanship is secured only by the closest supervision and painstaking inspection. Though there be no desire to slight the work, the workmen are out of sight and simplicity of details is essential.

Under these conditions, the cost of plates of uniform thickness, considering the cost of forms and their handling, and of the reinforcement and its placing, is less than that for an alteration of beams and slabs, and compensates for the additional material required.

It is probable that with the advance being made in the production of assembled reinforcement handled in units, construction of roof with an alteration of beams and slabs may be found advantageous, since economies may result to compensate for the additional expense now entailed by such designs, and methods devised to secure good work under the difficult conditions.

Since it is desirable to take the depth from the street surface to the passenger platforms as little as practicable, and the distance from the top of the roof to the street surface is usually determined by the space necessary for the water and gas mains, electrical conduits and other underground structures, the arched roof is often objectionable owing to the increased depth of the structure due to the rise of the arch. Flat roofs have been mostly employed with a moderate slope for drainage.

Flat roofs are built of cross beams of girders with jack arches of concrete, and also of reinforced concrete alone. Due to the considerations previously described the reinforced-concrete roofs have been of plates of uniform thickness.

Since the drainage grades on flat roofs are slight, and accidental leaks in roofs are more objectionable than when they occur in side walls waterproofing is always used.

In comparisons of the costs of roofs the item of waterproofing is common to all styles of flat roofs and reduces the elements of difference to the other features of the designs.

The execution of permanent and water-tight roofs with beams and concrete jack arches involves many details requiring care, and it may be said that greater simplicity and superior permanent results are obtainable with reinforced concrete alone.

With beams and jack arches, it is necessary to introduce reinforcement to prevent cracking due to shrinkage and temperature stresses, particularly immediately over the beams where the concrete is liable to crack and cause leaks, water tending to flow along the webs and flanges. Reinforced concrete in such places is superior to any other available material in securing enduring and water-tight work. Another source of leakage where beams are used is the thinness of the concrete back of the ends of the beams where they rest on the side walls. Such roofs require careful and efficient waterproofing; but little dependence should be placed on the waterproofing to bridge over or seal cracks in the concrete.

The cost of flat roof with transverse beams and jack arches of concrete is found to be cheaper than reinforced-concrete roofs with plates of uniform thickness. This is partly due to a lack of economy in using plates of uniform thickness, and partly to construction detail.

From the foregoing it appears the first cost of a two-track subway with reinforced-concrete side walls and a roof with beams and concrete and jack arches may usually be found less than that of a structure entirely of reinforced concrete, but such inference should be considered with caution for the reasons previously indicated. The difference in cost if in favor of the beams and concrete jack arches would be but a small percentage of the entire expense. On the other hand the permanent advantages of an entire reinforced-concrete structure are markedly great, and maintenance charges inseparable from composite structures of structural steel and concrete are eliminated.

As to the cost of various types of structure, it is possible that with space for masonry side walls in a subway for two tracks, and with the roof in one span and with favorable conditions economies might result, so that the cost of such a structure as a whole would not exceed that of one with thin walls of reinforced concrete and might be less.

Reinforced concrete permits the use of arched cross sections in cases where plain concrete or brick masonry would involve uncertain stability under the action of concentrated loads, particularly with the probability of the excavation of trenches parallel to and along side of the structure. Consideration of the latter contingency is imperative due to the growing demand in cities for underground service for public utilities, and the growth of municipal improvements by which increasing space is required beneath the streets.

In addition to the side walls and roofs of subways, concrete, plain or reinforced, is well suited to the construction of floors, inverts, platforms, stairways and other parts of underground railways. By using the precautions to exclude water by proportioning the constituent and reinforcement concrete may be used for inverts or floors to better advantage than any other known material. This statement applies also to sumps, pumping chambers, underground passages and other deep construction, good results being attainable with less expense than with any other material and much less difficulty.

An interesting demonstration of the advantage of reinforced concrete occurred in the building of the Market St. subway in Philadelphia, between the City Hall and the Schuylkill River, at 21st St. A large water main on the north side of the street parted at the junction with a main on 21st St., the rush of water excavating a large hole in the street and carrying the debris into the uncompleted subway. A small egg-shaped reinforced-concrete sewer built as part of the drainage diversion caused by the subway construction, sustained itself as a bridge with a clear span a little over 40 ft. wide, and not only carried its own weight, but also a quantity of earth, paving stones and other debris. No fractures were found in the sewer, only some small cracks, and the leakage from the sewer which had been in service for some time, amounted only to intermittent drops. The washout was backfilled and the street repaved without the necessity for any repairs to the sewer. The incident confirmed the judgment exercised in the beginning of the work, to build the new sewers parallel to the subway of reinforced concrete.

In conclusion the author feels it necessary to recognize the fact that the matter presented does not completely comport with the title of the paper since comparisons by figures of the cost of concrete and reinforced concrete for subway construction are not included. Regarding the data as to the cost of subways in several cities, representing various practice, it was not found practicable in the time available for the preparation of the paper, to prepare such comparisons, as so many diverse conditions, unless carefully considered, would make them of no practical value. Comparisons of the cost of modern and obsolete types have not been made, as they would be of interest only to curious.

Diagrams for Rivet Pitch in Load... Girder Flanges.

By P. L. PRATLEY.*

Assume that the curve of total ...ar in a girder is a parabola with vertex at rig... and end of span (Fig. 1). This is not strict... accurate, as it makes the total shear vary in... same manner as the live-load shear. Th... error involved appears from Fig. 2, where ... plotted the curves of dead-load shear, live-...d-shear, total shear found by adding these and ...tal shear according to the above assumption. ... shaded area represents the error of the assu...tion. It will be seen that the error becomes ...ceptible only near the center of the span, and ... on the safe side, showing a greater shear (hence closer rivet-spacing) than the theoretical ... amount.

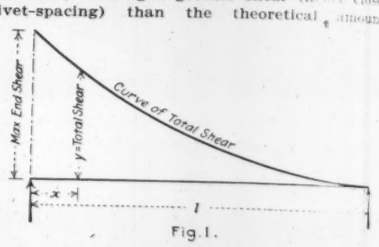


Fig. 1.

Further, the rivet-spacing near mid-span is usually governed by the specifications for maximum permissible pitch rather than by the shear requirements. The assumed curve may therefore be taken as correct for all practical purposes.

The equation of the shear curve, Fig. 1, referred to the left-hand end of the base-line, is

$$y = K\,(l-x)^2$$

the constant K depending on span and end-shear.

The amount of flange-rivet resistance required, or the longitudinal shear, per lineal inch, is found from the transverse shear by dividing by the effective depth of girder, D. If the value of one rivet be called R, the required number of rivets per lineal inch, at a point whose abscissa is x, is found from the above formula to be

$$\text{No. rivets at } x = \frac{\text{shear}}{RD} = \frac{K\,(l-x)^2}{RD}$$

and the required pitch of rivets is the reciprocal of this, or

$$p = \text{Pitch at } x = \frac{RD}{K\,(l-x)^2}$$

This value may be plotted in a curve on a base-line representing the span, Fig. 3. The curve is a

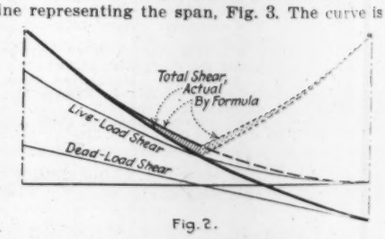


Fig. 2.

hyperbola, asymptotic to the base-line and to the vertical at right-hand end of span.

We are concerned only with that part of the curve which lies between $x = 0$ and $x = \frac{1}{2}\,l$, since on the right-hand half of the span the negative shear will govern rivet-spacing. This left-hand part of the curve involves only finite values.

The general equation for p represents a family of curves, one for each value of K, which depends on the end shear and the length of span.

*Dominion Bridge Co., Montreal, Canada.

For known end shear on a given girder there is a fixed value of K, which fixes the equation for pitch. If the pitch required at the end of the girder be called p_o, we find its value from the equation for p by making $x = 0$, or,

$$p_o = \frac{R\,D}{K\,l^2}$$

From this we find

$$\frac{R\,D}{K} = p_o\,l^2$$

by which the equation for p may be transformed to

$$p = p_o \left(\frac{l}{l-x}\right)^2$$

EFFECT OF VERTICAL LOADS.—In the above analysis it has been assumed that flange

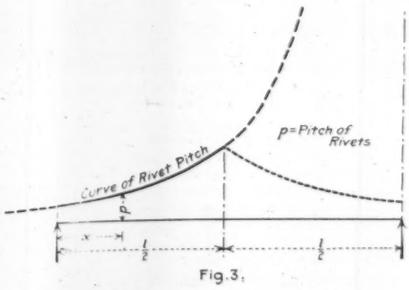


Fig. 3.

rivets of value R, and pitch p are good for a horizontal shear of R/p lbs. per inch run. But the rivets of the loaded flange must also carry a vertical load of S lbs. per inch run, so that there remains for horizontal shear only the amount

$$\sqrt{\frac{R^2}{p^2} - S^2}$$

Therefore, the pitch given by the previous formula must be decreased to a smaller pitch q defined by the relation

$$\sqrt{\frac{R^2}{q^2} - S^2} = \frac{R}{p}$$

or

$$q^2 = \frac{R^2\,p^2}{R^2 + S^2\,p^2}$$

Substituting in this equation the value of p already found, the corrected formula for pitch is obtained:

$$q^2 = \frac{R^2\,\dfrac{p_o^2\,l^4}{(l-x)^4}}{R^2 + S^2\,\dfrac{p_o^2\,l^4}{(l-x)^4}}$$

or

$$q = \sqrt{\frac{R^2\,p_o^2\,l^4}{R^2\,(l-x)^4 + S^2\,p_o^2\,l^4}}$$

If x be expressed in fractions of l, i. e., $x = a\,l$, this becomes

$$q = \sqrt{\frac{R^2\,p_o^2}{R^2\,(1-a)^4 + S^2\,p_o^2}} = p_o \frac{1}{\sqrt{(1-a)^4 + \left(\frac{S}{R}\right)^2 p_o^2}}$$

EXAMPLES.—1. By the Dominion Government specification, 1908, the allowable rivet value for 7/16-in. plate is $R = 7{,}660$ lbs. The loading Class Heavy gives a vertical load per inch of

$$S = \frac{24700}{36} \times 2 = 1370 \text{ lbs.}$$

Then in a girder for which $p_o = 2$ ins., the corrected pitch at the quarter-points ($a = \frac{1}{4}$) is:

$$q = 2\,\frac{1}{\sqrt{\left(\frac{3}{4}\right)^4 + \left(\frac{1370}{7660}\right)^2 4}} = 2\,\frac{1}{\sqrt{.316 + .128}}$$

$$= 2\,\frac{1}{.667}$$

$$= 3 \text{ ins.}$$

2. Take the Am. Ry. Eng. & M. W. Assn. specification, 1905, allowing for 3/8-in. web-plate a rivet value $R = 7{,}220$. The loading E 40 gives

$$S = \frac{20000 \times 2}{36} = 1111 \text{ lbs. per in.}$$

Then if the uncorrected end pitch $p_o = 1\frac{1}{2}$ ins., the corrected pitch at one-third the span ($a = \frac{1}{3}$) is

$$q = 1.5\,\frac{1}{\sqrt{\left(\frac{2}{3}\right)^4 + \left(\frac{1111}{7220}\right)^2 2.25}} = 1.5\,\frac{1}{\sqrt{.197 + .053}}$$

$$= 1.5\,\frac{1}{.50}$$

$$= 3 \text{ ins.}$$

DIAGRAMS FOR FORMULA.—In the accompanying diagram Fig. 4, are plotted the curves for uncorrected pitch

$$p = \frac{p_o\,l^2}{(l-x)^2} = \frac{p_o}{(1-a)^2}$$

for different values of p_o. To derive from them the values of corrected pitch q, as required by the expression

$$q^2 = \frac{R^2\,p^2}{R^2 + S^2\,p^2}$$

new ordinate scales are constructed. As R and S both enter into the reduction formula, each different specification will require a different scale. The scale is obtained by evaluating q for values of p, R and S; so that by measuring the ordinate p at any point of the span and scaling it off on the particular scale, the pitch q is read.

Thus in the diagram Fig. 4, if p_o be calculated to be 1½ ins., then for the Dominion Government 1908 Class Heavy loading and 7/16-in. web-plate at a point 3/8 of span along girder the corrected pitch is found to be 3⅛ ins.

The diagram Fig. 5 is an example of the curves

$$q = \sqrt{\frac{R^2\,p_o^2}{R^2\,(1-a)^4 + S^2\,p_o^2}}$$

for the values of R and S indicated. In this diagram the ordinates are read directly on the scale to which the curves are plotted. The results are, of course, exactly the same as obtained by the diagram Fig. 3.

The diagram Fig. 5 must be plotted separately for each different specification, and is thus more especially useful only when a great amount of work is done to one specification, which, however, is the usual state of affairs with bridge companies.

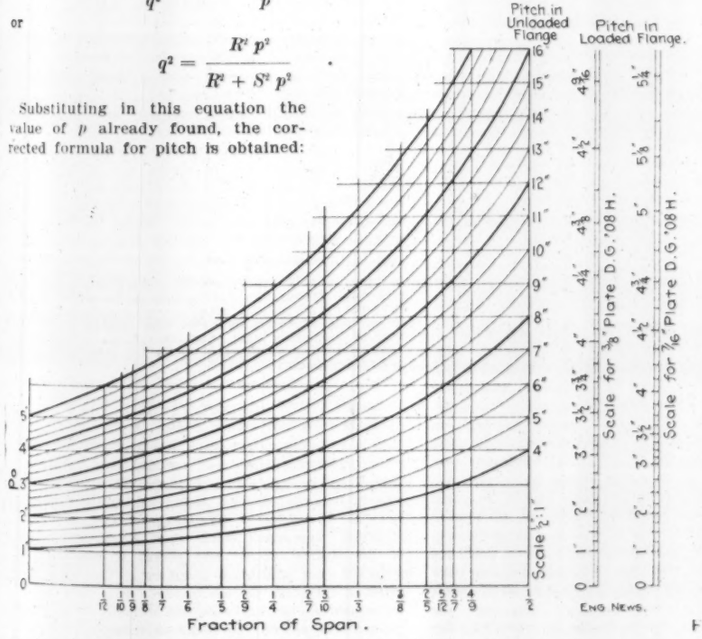

Pitch in Unloaded Flange
Pitch in Loaded Flange.
Scale for 3/8" Plate D.G. '08 H.
Scale for 7/16" Plate D.G. '08 H.
Scale ½":1"
Fraction of Span.
ENG. NEWS.

FIG. 4. DIAGRAM FOR RIVET PITCH IN PLATE-GIRDER FLANGES.

For different values of end pitch p_o.
Calculate p_o by:

$$p_o = \frac{\text{rivet value} \times \text{eff. depth of girder}}{\text{max. end shear}}.$$

If part of web is included in flange area, the pitch at any point may be multiplied by

$$\frac{\text{flange area} + \text{available web}}{\text{flange area}}.$$

Scales to right of diagram give ordinates for pitch in loaded flange.

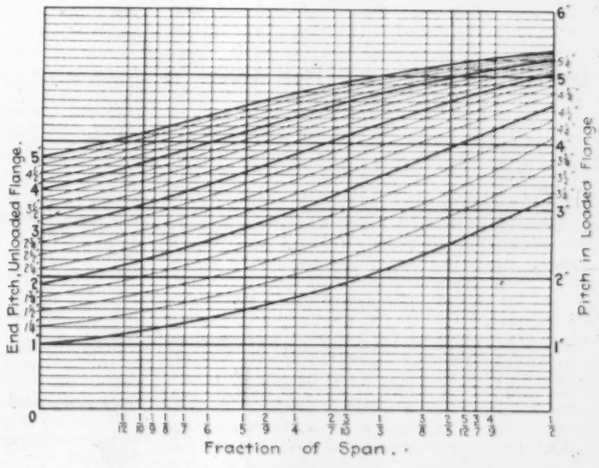


FIG. 5. DIAGRAM FOR RIVET PITCH IN LOADED FLANGES.

For different values of unloaded end pitch p_o.
For ⅞-in. rivets in 7/16-in. plate at 20,000 lbs. per sq. in. (rivet value 7,699 lbs.) and vertical loading of 49,400 lbs. on 36 ins. = 1,370 lbs. per lin. in. [= wheel load on one rail + 100% impact.]
Calculate p_o by:

$$p_o = \frac{7{,}660 \times \text{eff. depth of girder}}{\text{max. end shear}}.$$

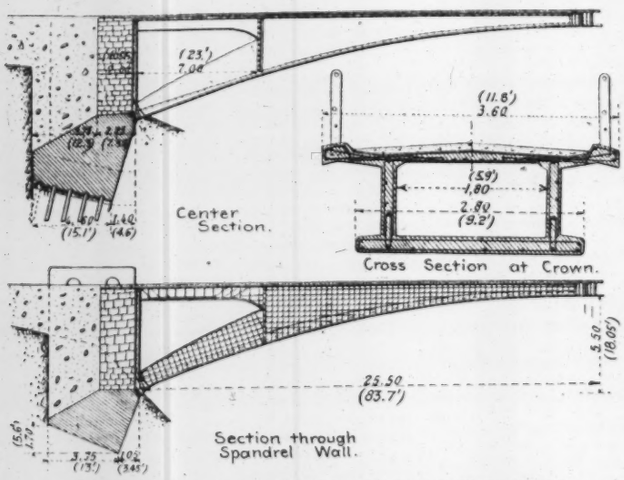
If part of web is included in flange area, the pitch at any point may be multiplied by

$$\frac{\text{flange area} + \text{available web}}{\text{flange area}}.$$

A Light Reinforced-Concrete Highway Bridge.

In the accompanying cut is shown three drawings of a remarkably light reinforced-concrete arch bridge which has recently been completed across the Vorder-Rhein, a branch of the Rhine River, at Tavanasa, Switzerland. The general construction, as will be noted from the figures, is a three-hinged arch rib for the entire width, carrying a slab roadway on thin spandrel walls, which are lightened by an opening near the abutments. On the side of these openings toward the center of the span, there is built a vertical transverse diaphragm, tying together the slab, the arch-rib and the spandrel walls.

The arch has a span of 167.3 ft., a rise of 18 ft. and a width of 11 ft. 10 ins. The rib is 7⅛ ins. thick and is reinforced longitudinally with ½-in. round rods spaced 15 ins. c. to c. and transversely with ⅝-in. rounds spaced every 12 ins. The spandrel walls are 6¼ ins. thick and are reinforced with criss-crossed ¾ and ⅝-in. rods. The transverse diaphragm is 4 ins. thick and reinforced. The floor, for ordinary country traffic, is 4¾ ins. thick and is reinforced with ⅜-in. rods, spaced 7 ins. c. to c. For the three hinges lead joints are employed. About 130 cu. yds. of concrete were used in the construction and the entire cost was $5,400.



DETAILS OF A SWISS REINFORCED-CONCRETE BRIDGE.

The accompanying cuts and description originally appeared in Le Genie Civil.

Concrete Monolithic and Pipe Sewers at Richmond, Ind.*

By FRED. R. CHARLES† and DELL B. DAVIS.†

Sewer work has been done the past year at Richmond which embraces some novel features. The principal point of interest is the use of concrete, both in monolithic form and in reinforced-concrete pipe.

The Northwest Second St. sewer was constructed under two contracts, one by Philip Hipskind & Sons, and the other by Lewis Hall, at an aggregate cost of $25,000. The excavation was almost entirely in rock, with a maximum depth of 18 ft. The diameter is 48 ins. for 75% of the length, and 42 ins. for the remainder. This was all constructed of monolithic reinforced concrete in the trench. A subdrain of 6-in. common tile was first laid. This took care of all the water entering the trench, leaving a hard and dry bottom on which to place the concrete with no danger of having it washed or disturbed by water. On the first half of the work, the collapsible centers of the Blaw Collapsible Steel Centering Co. (Pittsburg) were used. These were semicircular in shape, and after forming the invert, were drawn ahead, and others used for the arch.

Beginning the work, the trench was first shaped to conform to the sewer, leaving 6 ins. for the thickness of the concrete shell. Then for the flow line, a strip of concrete about 2 ft. wide was laid (as in sidewalk work) between rails, which were notched at intervals of 6 ins. to receive the reinforcing rings. At the end of each section of convenient length, templates were set, on which straight edges were drawn to give the proper circular shape to the flow line. The reinforcement used at first consisted of ½-in. longitudinal rods and circumferential bands. The latter were in two portions, bent to the required radius, and long enough to give a good lap at the springing line. The lower rings were held in place by the notches in the side rails while the flow line was being placed. When the flow line was set sufficiently, the half-round forms were placed thereon, and the concrete was deposited. When this was hard enough, the arch forms were drawn ahead; the reinforcing rods and rings were put in place and wired together. Then the arch concrete was put in, and finished over the top with shovel and trowel.

This method of reinforcing, while affording ample strength, proved not quite satisfactory. This was owing to the difficulty in spacing the metal and holding it in place, it being very tedious work to place and wire together. Consequently expanded metal was substituted and found much easier to manage. In using this, the rails for forming the flow line were discarded. The concrete was placed on the trench bottom, up to a point 2 ins. below the grade line. On this was laid the expanded metal in sheets bent to the required radius of the sewer, and extending some distance above the springing line, to allow for lap on the upper portion. Then at intervals corresponding to the length of the straight edge at hand, were set heavy blocks, cut to the radius of the sewer, and set to the proper grade. Using a straight edge between these blocks and the finished surface of the preceding section, the concrete was leveled off to the proper grade. Then the remainder of the sewer was constructed as before.

On the second section of this sewer, the form used was that made by the Adjustable Steel Centering Co., of Fond du Lac, Wis. This form is a full circle, allowing all the sewer above the flow line to be constructed at one operation.

All concrete was made of Portland cement, and good, clean bank gravel, proportioned 1 to 5. It was made thin so that it would almost run or pour, and then agitated so as to eliminate air spaces and force the cement to the surface of the forms. With proper care this method gives a smooth, hard surface. The concrete was mixed as close to the trench as possible, but a short wheelbarrow haul was necessary. The average labor-hours per lin. ft. for building the sewer, using Blaw forms and expanded metal reinforcement, were as tabulated below. This includes all the labor, but not the concrete mixing machine:

	Labor-hours per lin. ft.
Placing flow line	0.48
Setting invert forms	0.5
Concreting invert	0.44
Setting arch forms	0.33
Concreting arch	0.33
Foreman	0.25

The other sewerage system was about 4½ miles in length, ranging from 54 ins. to 12 ins. diameter. This was largely rock excavation in depths averaging 9 ft., with a maximum of 13 ft. The 54-in. size was in an open ditch or water course, and consequently was practically above ground. This 54-in. section was built in horse-shoe shape, with a "V" shaped bottom. The shell was of monolithic concrete, 7 ins. thick, reinforced with expanded metal. In operation the bottom was placed like ordinary sidewalk work, with the sides carried up about 18 ins. at the second operation by means of wooden forms. The metal reinforcement was bent to the proper shape and carried up far enough to make a good lap with the top section. For the arch a half-round Blaw form was used. For the 42-in., 30-in. and 24-in. sizes, reinforced-concrete pipe was employed. The pipe was made under the Sheets system by the Mercantile Bridge & Concrete Tile Co., of Paris, Ill., and delivered to the contractors (Philip Hipskind & Sons) along the line of the trench. By this system the pipes are made in forms, consisting of an outside shell and an inner collapsible form, resting on a base plate or pallet.

The reinforcement is expanded metal. The end of each pipe is notched or rabbeted for half the thickness of the shell. This rabbeting is on the outside of the pipe for half the circumference and on the inside for the other half. In laying, the pipes are so placed that this notch forms a groove at the joints, being on top of the upper half and on the inside of the lower half [illegible] the pipe. By this means the joints are cemented [illegible] always accessible from the last pipe laid, and [illegible] plastering the mortar downward. After being made [illegible] pipes were allowed to season at least two weeks [illegible] being laid. For handling and placing the pipe in the [illegible] or tripod derrick was used, with a [illegible] chain hoist, as the pipes are quite heavy [illegible] 30-in. pipes were made in 3-ft. lengths [illegible] pipes in 30-in. lengths. The average cost [illegible] laying these sizes was as follows: 8.3 cts. for 42-in., 6 cts. for 30-in., and 5.3 cts. for 24-in.

Our experience showed that for a dry [illegible] with firm banks the monolithic work is the cheapest if water is encountered, or treacherous soil, or if backfilling must be done immediately, the pipe is more advantageous. The pipe has the further advantage of being made under good conditions, and easily inspected, so that a more uniform quality likely to be attained.

As the discharge of this sewerage system [illegible] into a small stream, some method of purification was deemed necessary. At the end of the present system an overflow manhole was built, so as to permit the storm water to overflow and continue down the present open channel, while the ordinary flow is carried in vitrified pipes about half a mile further to the disposal plant. Eventually, of course, the entire flow must be cared for, but at present it seemed advisable to permit the storm water to continue in the present open channel.

The disposal plant has first a settling chamber, 10 × 10 ft.; then a bacterial tank, 20 × 102 ft., built of reinforced concrete, with a roof of wood and felt. From the tank, the sewage is distributed, by means of "Miural" automatic alternating siphons (made by the Pacific Flush Tank Co.) onto one of four filter beds, consisting of 3 ft. of fine gravel. Each bed is about 50 × 100 ft. The distribution is through vitrified pipe and cypress lumber distributers. The collection is by five rows of common farm tile, in each bed, leading into sewer pipe outlets. As the construction was only finished a short time ago, no results of the operation can be given as yet.

*Abstract of a paper read at the annual meeting of the Indiana Engineering Society at Indianapolis, Ind., Jan. 14-16, 1909.

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A PUBLIC SERVICE COMMISSION for the State of Vermont was created by a bill recently passed by the Legislature, which will take effect on April 1, 1909. The Commission will be the existing Railroad Commission, with powers and duties enlarged. Under the act named, the Commission will supervise all the railways, gas and electric lighting plants, telegraph and telephone lines and express companies of the state. These various companies will be required to supply the Commission such information as it may desire from time to time, and must submit to the Commission written reports of any and all accidents connected with their works which result in "loss of life, or injury to any person which will incapacitate him from engaging in his usual vocation." It shall be the duty of the Commission to investigate all such accidents, holding public inquiries if deemed advisable. The Commission is given particular jurisdiction of the "purity, quantity or quality of any product furnished or sold by any company under supervision," and is also given power to amend rates for public service. Issues of stocks and bonds are also subject to the approval of the Commission. The salaries of the commissioners are fixed at $1,700 per annum and necessary expenses, besides which the chairman is to have $500 additional. The act creating the Commission specifically states that

nothing in this act or previous statutes shall be construed as giving the Public Service Commission power to prevent or restrict competition or limit the number of persons or companies who may engage in the business of furnishing light, heat, power, or any other business subject to supervision under the provisions of this act in any town.

INOCULATION AGAINST TYPHOID FEVER is to be permissive in the United States Army, in accordance with a recommendation of a board of medical officers, which recommendation has recently been approved by the Secretary of War. This board included, among others, Brigadier-General Robert M. O'Reilly, Surgeon-General, Dr. Victor C. Vaughan, of the University of Michigan, Ann Arbor, Mich., Capt. Frederick P. Russell, of the Medical Corps, who served as recorder. It is proposed that individual members of the army be invited to volunteer for vaccination. Vaccination will not be compulsory in any case, but lectures and other educational means will be taken to induce soldiers to be vaccinated. The vaccine is introduced by means of hypodermic injection into the arm. After a few hours, it is stated, a little fever or headache results, and the spot on the arm becomes tender. It is said that the spot never becomes sore and that it disappears in two or three days. About 100,000 soldiers were inoculated against typhoid in this same general way in South Africa during the Boer War, but no satisfactory records are available of the results obtained. Within the past few years it is said that 15,000 men have been treated in this way, with excellent results and without a mishap.

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The Commission of Engineers which accompanied President-Elect Taft to the Isthmus to examine the canal works returned to the United States on Feb. 11 and proceeded to Washington to complete the drafting of its report to President Roosevelt. The report will probably be delivered to the President during the present week. From public statements made by Mr. Taft since his return, it is known that the report of the Commission will carry full approval of the lock canal, will certify to the entire safety of the Gatun dam and will give the American public full assurance that the work at Panama is being carried on by absolutely sound engineering methods.

It is probable that the report will be available for publication in full in our next week's issue, and pending that we forbear to comment further on the situation on the Isthmus.

As for the situation in the United States, the remarkable newspaper campaign to bring about a change to the sea-level plan of construction still continues. It is significant that the newspapers which have been most prominent in this campaign are those which are well known to be controlled by interests closely identified with Wall St. financiers.

It is significant also that in their attacks on the lock plan of construction and the attempts to advocate the sea-level plan, many of the statements and figures presented are absolutely false. This applies also to statements with the same object recently made in the U. S. Senate and widely circulated throughout the country. We do not make this statement lightly; but with full knowledge of what the real facts are.

Now why should these various prominent public journals engage in this campaign for the sea-level plan? Why should they give wide circulation to statements absurdly false? Why should they undertake attacks on the personal reputation of some of the most eminent and honored engineers in the profession, who have been connected with the working out of the present plans at Panama? Why should they at the same time pretend to take seriously the claims and opinions of one or two charlatans who have no professional standing as engineers, who have "butted-in" with pet schemes and inventions which they want to advertise? Are these great metropolitan journals really so ignorant as to suppose that each "Gnu-Gorilla" who comes along with a new invention to use on the Panama Canal is really an "Eminent Engineer"?

We submit these questions to the intelligence of our readers for we feel that there is no need to answer them categorically. To an understanding mind it is not difficult to guess at the mainspring that furnishes the motive power for all these virulent attacks on the present work at Panama.

That the campaign for the sea-level plan can be successful, however, there is not the slightest reason to suppose. The newspapers dominated by Wall St. interests in no way represent the public sentiment of the country. The reputable journals in other parts of the country, we find, are shrewd enough to gage the agitation promoted by Wall St. at about its true value. And the public is pretty certain to be guided in its opinion on canal matters by the opinions of the leading members of the American engineering profession.

We can say authoritatively on our own responsibility and with full knowledge of the facts that the work at Panama is proceeding in a manner of which every American engineer may well be proud, and that the plans and methods adopted by American engineers and being carried out by American engineers are absolutely sound and safe. And we shall have much more to say on this subject in following issues.

A worthy attempt to improve the administration of the building laws in the District of Columbia has been made by the introduction into the House of Representatives of a "Bill to Regulate the Licensing of Builders in the District of Columbia." This bill has been referred to committee and probably will remain there throughout the present short session, for it has many defects of detail and is opposed by the building trades of Washington, but it is a step in the right direction and indicates a thoughtful mood upon the subject on the part of those in authority.

In short, the bill provides for a licensing board —to consist of one architect, one builder and one member of the local building department— which shall have the authority to examine applicants for building licenses and to recommend the issue of the licenses. It further provides for the establishment of four gradated classes of buildings, varying from the first class, which comprises "building construction requiring extensive knowledge, experience in the strength of materials and the application thereof to buildings," to the fourth class, of small buildings personally erected by the owner for his own use. The exact distinction between the classes is not made very clear, but is expected to be determined by the Commissioners of the District. All building licenses are to be divided into four grades, corresponding to the above classes of buildings, and the holder of any one is thereby authorized to do the work in his class and in all lower classes. Gradated entrance fees into examinations and annual license fees are also provided. Each licensee must give bond to protect the local government from any loss resulting from his illegal or negligent acts, but no provision is made for the pecuniary protection of the owner in the case of negligence by the licensed builder; the legality of this latter provision is probably questionable. Such protection as is granted owners is therefore entirely precautionary. Failure to procure a license by anyone engaged in building or failure to employ a licensed builder on the part of the owner is punishable by fine or imprisonment.

The city of Washington, as we have many times said, is the proper place for the primary introduction of municipal reforms. Its crowning position as the capital of the country make it the observed of all municipal observers and the acknowledged integrity of its government offers the best chance for a faithful administration. It is therefore unfortunate that this needed reform in building laws should be attempted in such a superficial manner as is indicated in the bill now before Congress. In that bill, so much is left to the discretion of the licensing board and to the District Commissioners that the exact working of the law, if enacted, must be largely a matter of judgment, or at least of interpretation, hampered by a few arbitrary distinctions that hardly seem necessary. Thus, four classes of buildings are prescribed but the boundaries of each class are not defined. And upon the proper subdivision of these classes and upon the method of determining the eligibility of the applicants for licenses the success or failure of the law hinges.

The matter then reduces itself to the proper duty of the legislative body in formulating such a law. In the present case the conditions are peculiar, so no rule can be laid down. The federal Congress, (or at least the committees on the District of Columbia in that Congress) is supposed to be the city council of the District of Columbia, but, as time and again it has been proved, this council does not give the attention that could be expected from a locally elected body. In the case of state legislatures or city governments, however, it would seem that, in the framing of such a law as that proposed for Washington, in which a commission is appointed for the regulating of some trade, profession or public utility, two courses are open. Either the exact details of the duties of that commission should be enumerated, or, what is infinitely better, the general purpose, jurisdiction and authority of the commission should be stated and the details of administration left to the commission itself, as in the case of the Interstate Commerce Commission and the various state public service commissions. Any legislation half way between the two above-noted schemes must be confusing and arouse the antagonism of everyone whom it is intended to affect.

With far more zeal than knowledge, the friends of forests succeeded some years ago in getting inserted in the Constitution of the State of New York certain prohibitions against cutting trees in the State forestry reservation and against flooding forest lands. But in making these prohibitions, the true interests of forestry were entirely lost sight of. In the fear that private individuals or corporations might cut and steal timber, it was made impossible for the State itself to cut down and utilize a tree, even though that tree was past its usefulness or already dead. It was also made impossible to construct dams or reservoirs that would flood State lands, no matter how little injury this might do to any of the forested area or how beneficial it might be to the State as a whole or any municipality that might need to store water on some stream in or flowing from the State reservations. As a result of these unwise and uncalled-for prohibitions, the State cannot pursue a complete measure of forestry operations and the State Water Supply Commission finds itself blocked in some of its most important plans for developing water storage and water-power for the benefit of the public. The latter phase of the subject is discussed in detail on the following page.

It seems high time that intelligent and widespread agitation was begun for the repeal, or perhaps more properly the modification, of this constitutional amendment, to the end that the Forest, Fish and Game Commission, which has been doing excellent work of late, should be enabled to administer the State forest reservations in accordance with the modern forestry principles which are now being carried out by the Forest Service of the United States and those of foreign countries. It should be possible to utilize dead and dying timber and even, if deemed necessary, to cut healthy and growing timber where thinning is necessary, and utilize it as well. By such means, revenue would be gained which would provide funds for the extension of forest planting on areas now bare and well-nigh worthless; or these funds might be used to improve trails and open up roads so as to make the reservations more accessible to *all* the people. In addition it should be made possible to construct dams and reservoirs in the

reservations wherever this can be done without greater injury than benefit to the public.

The present unfortunate restrictions are probably in a very large measure due to the feeling that the only way to prevent private individuals and corporations from exploiting the timber in the State reservations was to prohibit absolutely the cutting of a tree, dead or alive, even by the State itself. We hope and believe that it is not really necessary for the greatest State in the Union to rely on so abject and miserable a method as this for defending and protecting its property.

What will appear to most Americans as an unusual and unreasonable method of charging for water is in general use in Great Britain and is just now giving rise to some complaints in London. These complaints, however, do not seem to be directed so much against the method itself as toward a leveling process made obligatory on the Metropolitan Water Board upon its taking over the water-works formerly owned and operated by the eight companies supplying what is known as "Water London." At the time of this taking over, the rates charged by the several companies to occupants of houses and other buildings in London ranged from some 3% to 11% of the "ratable value," this value being substantially, as we understand it, the sum for which a given building is either rented, or, in case of ownership by the occupant, rentable. The date for a level rate having recently arrived, the Metropolitan Water Board has fixed this at 5% of the annual value of the property supplied. Presumably, those whose rates are lowered are keeping very quiet, but where the rates have been raised it is not surprising to hear there is much complaint. Inasmuch as property values are highest in the restricted and congested area known as the City of London, the change falls heaviest there. This, of course, implies that previously that wealthy section of Greater London was enjoying relatively low water rates. Those who are accustomed to water rates based or supposed to be based on the amount of water consumed will wonder why the common British system of basing rates on the rental value of property should ever have been adopted, or, adopted, why it is not being given up by this time. The fact that the rental value of a building near the Bank of England is two to ten times as high as that of a building in one of the outlying boroughs, affords no reason, on the face of it, why water charges for the first building should be any higher than those for the second. If it be said that the use of water will be greater near the Bank of England than in an outlying district, then, we may ask, why not proportion the rate accordingly?

Conflicting specifications for copper wire, designed for use in the electrical industries, have given rise to considerable complaint and confusion during the past few years. The trouble seems to have steadily increased and a few engineers have expressed the hope that the American Society for Testing Materials or the American Institute of Electrical Engineers would see fit to study the situation and prepare standards for the copper wires required for various services. The need is greatest in electric railroading, where the duty imposed on the trolley wire is most trying and the results are most unsatisfactory. There is a marked contrast to the duty required of wire used in electrical machinery where the important characteristic is conductivity. The overhead trolley line has not the simple duty of transmitting electricity, though that is its primary function. Even in the best of installations the wire is under continuous and varying tension and is subject to peculiar varying strains and distortions. The common overhead construction of the majority of city and interurban electric railroads with its rapid wear, increasing electrical resistance and heat loss, frequent breaks and demand for replacement and with its high first cost is probably the worst economic problem with which an overburdened manager has to contend. For economic length of useful life the trolley wire must combine with high electrical conductivity the best possible combination of three other qualities—high tensile strength, great flexibility and toughness.

Mr. Woods, in the paper reprinted in this issue, has clearly and concisely shown the purchasers of copper trolley wire what tests should be performed and on what lines specifications must be built to secure material for the best possible service. We believe this paper will also be read with interest and profit by all persons having to specify requirements for copper wires for any service. It may well serve to bring the general complaints of confusion and economic waste to more definite discussion and to help in securing adequate remedies generally.

This paper shows the economy of using high-grade wire in railroad overhead lines for longer useful life; it shows how the best product is to be obtained in the mill and at what cost. Mr. Woods only suggests the exceedingly important influence, on the useful life of the trolley wire, of subsequent handling and use. In the familiar trolley line even with the best quality of hard-drawn copper wire, carefully strung, there exists one great fault militating against safety and economy. It has long been evident that the common clamped or soldered "ear," by which the trolley wire is supported, needs to be discarded. We believe that, even where the simplest and least expensive lines are demanded, a comparatively simple and inexpensive "ear," or arrangement of "ears," can be devised to relieve the stresses in the wire at the points of support. Such a support might perhaps be like one, reported to be in successful use in England, described in Engineering News, Feb. 6, 1908.

A Water Conservation Program for New York State.

Great as must be the part of the national government in conserving and developing the natural resources of the country, it is upon the several component states that the bulk of the work will fall. This is true even of those Western states in which lie our remaining public lands. Elsewhere, and in the majority of the states, the general government has no ownership of natural resources and only such control as is incident to its jurisdiction over navigable streams and as comes from its general power to regulate commerce and protect the public welfare. How far-reaching these incidental and implied powers may prove to be only the future can tell. Some measure of cooperation between the United States and the several states will be required to ensure the fullest measure of utilization and control of numerous streams and lakes, but it is too early to say how far this will go.

Pending the time when public sentiment has crystallized sufficiently to determine the relative parts which the nation and the several states will take in these matters it is the duty of each state to work out a program for the conservation and utilization of its own water resources. How ably this has been done for one state may be seen from the abstract of the report of the State Water Supply Commission of New York, to which we devote a number of pages elsewhere in this issue. The work on which this report is founded and the possibilities and policies which the report sets forth place New York far ahead of its sister states in attempts at water conservation and utilization. Created in 1905, more particularly to ensure equity in the taking of water for municipal purposes, the State Water Supply Commission of New York has since inherited the results of earlier State investigations of water storage and of flood prevention and has been entrusted with the task of devising

plans for the progressive development of the water powers of the State for the public use under State ownership and control.

In accordance with this legislative mandate the Commission submits general plans for large storage reservoirs on the principal river systems of the State, presents the results of a census of water-powers of the State, developed and undeveloped, formulates a policy as to where the State should stop and private capital begin in the development of power from [illegible] out constitutional obstacles in the [illegible] points [illegible] ecuting its program, and suggests [illegible] of ex- [illegible] for their removal. This is all high[illegible] diments [illegible] able. It remains to be seen wheth[illegible] mmend- [illegible] lature and the people of New York [illegible] e legis- [illegible] respective parts in carrying out t[illegible] lo their [illegible] sidered program. ell-con-

As to the water-storage projects [illegible] e Com- [illegible] mission, we need only say here that [illegible] include enormous reservoirs on the Sacand[illegible] nd the Schroon (tributaries of the Hudson[illegible] e Gen- [illegible] esee and the Raquette rivers, with [illegible] r stor- [illegible] age on the Delaware. These reserv[illegible] together would add several hundred thou[illegible] horse- [illegible] power to that already available [illegible] existing power sites, besides making possible [illegible] reation [illegible] of large power plants at or near [illegible] several proposed dams. In addition, navigati[illegible] would be materially aided in the case of the Hu[illegible] n River, thus suggesting the possibility of [illegible] eral co- [illegible] operation; floods would be lessened a[illegible] number [illegible] of points, more particularly on the Ge[illegible] see; mu- [illegible] nicipal water-supplies would be reg[illegible] ted and [illegible] increased; and forests would be [illegible] nserved, through the more ready substitution [illegible] electric [illegible] for steam locomotives and the cons[illegible] ent re- [illegible] duction of forest fires.

The storage which would result from the construction of the proposed reservoirs would furnish a considerable part of the 1,000,000 HP. which, according to the census taken by the Commission, awaits development on the streams of New York State. Plans for further storage, the Commission asserts or implies, may be expected in the future.

The Commission has assured itself that owners and users of power at existing power plants would willingly pay the state for the additional and steady power which would be secured by storing flood waters in the proposed reservoirs, for equable discharge in the dry months of the year. This would reimburse the State for its outlays while at the same time greatly benefiting power users, stimulating industry and benefiting scores of cities and villages and many thousands of employees.

In order to put the matter of reimbursement to the State beyond doubt the Commission proposes, as a condition-precedent of construction, petitions from prospective power users, asking for water storage and stream-flow regulation, the petitions to be accompanied by guarantees of proper returns on the amount invested by the State. These returns, it is important to note, would be sufficient to redeem the bonds issued for construction and other capital outlays in 40 years time, besides taking care of interest, operation and maintenance charges.

The plan just outlined makes no provision for power plants and electric transmission lines to generate and distribute the scores of thousands of horse-power created by the dams and reservoirs. Instead of State construction and operation of such plants and lines, the Commission proposes that private enterprise be enlisted. This would limit public funds and public administration, alike, to water storage, including a wise use of the water stored, and the collection of equitable charges therefor in order that the State might be reimbursed for its outlay. That is, the function of the State would be to conserve one of its great natural resources for the benefit of the whole public. The commercial transactions incident to the production, distribution and sale of power would be left to private enterprise, except that the State would provide and sell various quantities of what we may call crude water-power—so and so many thousands of foot-pounds of energy, delivered regularly throughout the year instead of irregularly according to the vagaries of rainfall and run-off.

This is certainly a conservative as well as a commendable program. It involves the minimum of State activity and outlay consistent with a complete scheme of water conservation and utilization. It is the only plan under which there is any working possibility of having each component of the waters of the State apportioned to various uses according to broad public needs instead of narrow private interests. It is the only way to prevent taking what the Commission

calls the "dream" of the possibilities of a river and the [illegible]king power developments and other possibil[illegible]s above and below for all time to come. [illegible]t must be remembered that the State can tak[illegible] far look ahead and has a horizon of 300 de[illegible] while private capital and enterprise is con[illegible] only with the present and has but a narr[illegible]orizon—no interest in the public save that p[illegible]n which contributes to its treasury. A com[illegible]y may be interested in water-power alone. [illegible] State is concerned with water-supply, f[illegible] prevention and navigation as well, and th[illegible] throughout each of every drainage area within its boundaries.

Some may think the program should go further in the way of State development of power. No one could ask it to go less far than is proposed, without urging that it should enter upon no water-storage construction whatever. Such a policy, we believe, would be suicidal, or if not that, dwarfing.

There remain for consideration two fatal obstacles to the execution of this admirable program, but happily they are removable. That is, they may be removed if sufficient enlightened public sentiment exists or can be created in New York State. Both obstacles are constitutional: One is a prohibition of a State bond issue of more than $1,000,000 a year for such improvements as this. The Commission proposes an amendment which would permit a total indebtedness of $20,000,000 "for the improvement of rivers by the building of storage reservoirs for the public welfare." If the program makes any serious appeal to the people of New York State this amendment can doubtless be secured, as was an amendment authorizing a $101,000,000 bond issue for canal improvements and another authorizing a $50,000,000 debt for State highway improvement.

The other obstacle to the water-conservation program bids fair to be more difficult of removal. But inasmuch as it is founded half on ignorance and half on distrust it ought to be possible to remove the foundations and the obstacle together. Moreover, the reasons for removing this obstacle go far beyond the matter of water conservation; so far, indeed, as to thwart to a large degree the ostensible object of ever placing the obstacle in the constitution.

We quote from the constitutional amendment of 1894 as follows:

> The lands of the state, now owned or hereafter acquired, constituting the forest preserve as now fixed by law, shall be forever kept as wild forest lands. They shall not be leased, sold or exchanged, or be taken by any corporation, public or private, nor shall the timber thereon be sold, removed or destroyed.

Obviously, this bars flooding any of the State forest lands by reservoirs of any kind. The proposed Sacandaga Reservoir would flood 31 acres of State land and the Schroon Reservoir would flood 25 acres. The report of the Commission states that in both cases the fact that these small areas of State lands lie within the reservoir sites prevents construction—and the creation of some 200,000 HP. Whether or not the land in question lies so that a cut-off dam, in each case, would obviate the difficulty at reasonable expense we do not know. It is only fair to assume that it would not. However this may be, there seems to be no doubt in the case of a number of other promising reservoir sites. The 82,000 HP. possible of development by building a dam on the Raquette is barred by 4,380 acres of State land, of which the greater part is untimbered swamps. The value of the timber on the whole State tract involved, as well as other important and interesting phases of the subject, is discussed towards the end of our abstract of the Commission's report, elsewhere in this issue.

The Commission states that to store the flood water of all the Adirondack streams, so far as sites are available, would require the flooding of about 20,000 acres of State land, or 1.6% of the 1,262,776 acres in the Adirondack Park. But 15,000 acres of these lands, or 75%, are swampy, leaving but 5,000 acres of timber land to be submerged. The Commission proposes a constitutional amendment that would permit the State to flood 20,000 acres of its lands, the reservoirs in question to be forever owned and controlled by the State,

Elsewhere in the editorial columns of this issue there may be found a general discussion of this constitutional prohibition, which so effectually prevents any use of the Adirondack preserves except "as wild forest lands," and which prohibits not only flooding an acre for water-storage purposes but also prohibits the cutting of a mature or dying tree, or even one which is dead and down. We need say no more on the subject here, except to point out that provisions of this sort, which are so broad as to cover more than a million acres of land, constituting many of the most important of the headwaters of the State, and so detailed as to prohibit the cutting of a tree by the State itself, should rarely if ever be placed in a constitution. There remains, for instance, plenty of land outside the State forest preserves, just as valuable for purposes of health and recreation as much of that within, and which might advantageously be substituted for that within, in case it were of sufficient importance not to diminish the area of the State lands, even to secure such great public benefits as water storage and water-power.

This obstacle of flooding State forest lands sharply indicates the need of both a well-considered program for the conservation of natural resources, whether water, forest or mineral, and of strong and able commissions to deal with conservation matters. Had a modern forestry policy and the present water-conservation program been formulated 20 years ago there need never have been any difficulty in adjusting forestry, water and recreation interests to each other. Moreover, had there been, through all these years, proper State supervision of both waters and forests in the interests of the public neither the one nor the other would have been so often exploited for private gain that every proposition for the industrial use of the forests or the waters of the State of New York is likely to create a panic among those who wish to see natural resources reserved for public use and enjoyment instead of devoted to private gain.

Finally, we hope other states will follow the lead of New York and work out comprehensive plans for conserving and utilizing their natural resources, at the same time avoiding such ill-considered constitutional legislative restrictions as those relating to the Adirondack forests.

LETTERS TO THE EDITOR.

Subdividing an Arch Ring for Analysis.

Sir: In your issue of Jan. 28, 1909, appeared an article by Andrew B. White, giving a graphical method for subdividing an arch ring for analysis. The equation given by Mr. White I believe is not one which can be used, but his graphical suggestion is a very good one.

The principal drawback to the more universal adoption of the solution of the hingeless arch according to the elastic theory has been the labor it required, so that any short cuts and graphical aids which will reduce this labor are greatly welcomed. The part of the solution which requires the most work is finding the subdivisions which Mr. White has shown how to find graphically, but as explained by him there would be no saving in the work necessary. Referring to his notation and his sketch, he says: "$\frac{\delta s}{I} = \frac{s}{\Sigma I} = \frac{s}{n \times \frac{\Sigma I}{n}} = \frac{s}{n i_a}$. Having thus found $\frac{\delta s}{I}$" etc.

But this equation can not be used to find $\frac{\delta s}{I}$, which is the all important constant, because the values of I to be used in ΣI are unknown. The correct equation to use is:

$$\frac{\delta s}{I} = \frac{s i_a}{n}$$

the notation being the same as in the article except that i_a is the average value of i, this latter being the reciprocal of I. To find i_a it is necessary to find the moment of inertia at a number of points along the arch axis equidistant apart. Then, having thus found $\frac{\delta s}{I}$, one can proceed as Mr. White explains.

Very respectfully,

Harlan D. Miller.

Albany, N. Y., Jan. 29, 1909.

Sanitary Districts of Indiana and Chicago.

Sir: I note with interest in your issue of Dec. 17, 1908, some extracts from remarks by Mr. John W. Alvord relative to a proposed sanitary district for northern Indiana. Such a district properly organized should provide means for an ideal solution of the sanitary problems of that territory, and there should be the fullest cooperation between it and the Sanitary District of Chicago, as each could impart very useful information to the other and their interests are very closely related, for though a state line separates them it is but an artificial boundary.

While, as Mr. Alvord suggests, no doubt the Sanitary District of Indiana should be organized on a broader basis than was the Sanitary District of Chicago, yet the granting of that does not necessarily imply that the Chicago Drainage Canal project was a mistake from the start to the present time. And again, whether it was the best solution of the Chicago problem or not, considering its present status and the millions spent on it to date, would it not be worth while for a sanitary district of Indiana to look into the possibilities of profiting by the existence of the Chicago Drainage Canal before deciding against that method of disposal? [Disposal by dilution, by diverting water from Lake Michigan to the headwaters of tributaries of the Mississippi.—Ed.] Mr. Alvord seems to imply that the proposed sanitary district of Indiana should be free to weigh all facts and decide all its policies and methods impartially and yet he would have it start with the assumption that the drainage canal method is all wrong and to be avoided at all hazard.

He says:

> I am certain that we will one day have a great waterway from the Lakes to the Gulf, and again, I fully expect to see a channel of the Sanitary District of Chicago connected with the whole south shore of Lake Michigan and having upon it the commerce which is an ample justification for its construction.

That is quite a tribute to the (navigation) foresight of the projectors of the canal and especially to Mr. L. E. Cooley, coming as it does from one who has opposed the Drainage Canal project from its inception. Without the Drainage Canal and the consequent agitation of the waterway problem who can tell what would have been the present status of the whole subject of inland waterways?

As to the sanitary side of it, granting that simple dilution is not in general an ideal method of sewage treatment does not prove that it was not the best method for Chicago to adopt. Has there ever been any other method of disposal worked out far enough to prove that it was entirely practicable for Chicago and capable of extension as the city increases in population and area? The topography and soil of the surrounding country render the feasibility of any method of filtration or broad irrigation questionable. Not as much was known of septic tanks twenty years ago as to-day and I think it is yet to be proved that their application or that of any other method of purification is or ever will be as practicable for Chicago as the present one of dilution and discharge into the Illinois River. Any other method of treatment would involve much more extensive intercepting sewers and pumping stations to keep all sewage out of the Chicago River as well as out of the lake. Since nearly all the sewers of Chicago carry off the storm water, the intercepting sewers, tunnels, pumps and purification works would have to be of sufficient capacity to handle the total runoff from the whole area sewered or else the whole system worked over into the double separate system of sewerage, and who is brave enough to venture a guess as to what that would cost.

As to magnitude, the problem was not materially different twenty years ago than it would be now, since future growth has to be provided for in any event.

Considering all these points it seems to me that the projectors of the Chicago Drainage Canal showed rare common sense, keen foresight and good engineering ability in deciding to *combine sewage disposal with the promotion of navigation*, and that it is up to their sanitary opponents to show by figures that there were better methods of attaining *both* those ends or else stop urging or suggesting that the Drainage Canal project is all wrong.

Yours very truly,

H. P. Boardman,

Professor of Civil Engineering, University of Nevada, Reno, Nev., Dec. 26, 1908.

[Having submitted proof of Prof. Boardman's letter to Mr. Alvord, we received the following reply.—Ed.]

Sir: Through your courtesy I have been shown proof of a letter from Mr. H. P. Boardman, commenting upon my remarks upon the formation of a Sanitary District of Indiana. A careful re-reading of my remarks as quoted in the Engineering News of Dec. 17, 1908, would seem to me to answer most of the questions raised by Mr. Boardman.

My criticisms in those remarks are not so much directed to the question of the wisdom of past expenditure (which, nevertheless, I question) as to the troubles

which we now labor under in Chicago, through the operation of the law creating the Sanitary District. My original remarks state this fairly, and are as follows:

In my opinion the Sanitary District Law, limiting the District, as it did, to the construction of a certain kind of channel or channels, without the authority to build intercepting sewers, sewage disposal plants, water filtration plants, or to properly protect the water supply was a misdirected law, which has only in part accomplished its purpose, and which must inevitably be in the near future, entirely revised to meet the new situation of sanitary danger which is now impending over Chicago.

The Sanitary District Law of Chicago was originated by those who were desirous of seeing commerce channels created, making this their primary purpose. The result has been that neither have we channels for commerce which can be utilized for many years to come, nor have we the best methods of sewage purification or sewage disposal.

That our Channel for *Commerce* cannot be available for many years to come, is probably obvious. It has already been idle for eight years, chargeable, justly, with the difference between such interest, maintenance and depreciation loss as would lie between its actual cost and the cost of other equally good sewage disposal methods. The new $20,000,000 waterway to Utica (less than 100 miles away), now to be undertaken by the State, will, in my opinion, take at least ten years to build, and ends "in the air," so to speak. We must look to the national government for its extension to St. Louis, before it can be really useful. Suppose it is to be completed to St. Louis. Additional years must elapse before it is in full use and a profitable commerce, in an amount justifying its completion, can create itself, and interest loss, maintenance and depreciation are constantly going on to add to its capital account all of this time. How much per ton-mile will it then cost for the freight moved upon it? No one can fully answer, for the amount of its traffic must necessarily be a speculative proposition, about which no two opinions will, or can, fully agree. It is obvious, therefore, as a Chicago proposition, we have not yet obtained a Commerce Channel, nor will we for years to come, and when completed, its justification must still be demonstrated from an economic standpoint.

The second statement, that we do not have the best methods of sewage purification or sewage disposal, arises principally as a matter of cost, although secondarily as a matter of safety.

It is an interesting fact that, disregarding Commerce, Chicago has already expended, and will expend probably ten times as much for its sewage disposal as the city of Berlin, Germany, whose original works were well finished—and a good object lesson—before ours were begun. Both cities have equal facilities in the possession of accessible irrigable lands. Their population is, and has been, about equal. Berlin has found its plant economical to operate, as well as successful in method. Chicago has not yet finished its original project, and is now confronted with the fact that its water-supply is seriously menaced again.

It should be admitted, in all fairness, that our drainage channel has undoubtedly averted serious typhoid epidemics, but even here it must be questioned if other methods would not have accomplished the same thing at less cost and more quickly.

But these are reflections about the past. The Channel is completed and I have no time or inclination to discuss problems that are obviously to be relegated to the attention of the antiquarians. The troubles that confront the Sanitary District of Chicago to-day are how to profitably use the Channel now that we have got it, and as we are operating under laws which only permit our sanitary authorities to build channels and water power, we find this condition responsible for plunging us into many millions of additional expenditures for branch canals, where intercepting sewers, or sewage purification plants might perhaps be better and cheaper.

Take, for instance, the Evanston Branch Channel, now under construction. It can add no useful dilution water to the main canal. Dilution water as well as sewage must be pumped into it. It provides no additional depth for drainage,-and as a commercial waterway, its 60 ft. or so width must restrict it for commerce. An intercepting sewer would seem to me to have answered the purpose far better, but the Sanitary District, as I understand it, cannot even consider the building of intercepting sewers. Again, the U. S. Government limits the flow we can take from the lakes to 10,000 sec.-ft., which would be ample for this city for all time to come, if we could *tank* our sewage, dissolve the solids, and use this flow to dilute the effluent, but we are restricted by the Sanitary District Law, which says we must add a given amount of fresh water for each added increment of the population, regardless of the known practicable improvements in sewage purification.

Again, it is probable that it would be highly desirable to treat the outlying suburban and thinly settled districts of the city by sewage purification methods pure and simple, but we have no sanitary authority empowered to undertake such work, and, as a result, we find ourselves seriously proposing and building branch drainage channels of vast cost, especially as proportioned to present needs. The Evanston Branch Channel is to cost over $6,000,000, I believe; and the Calumet Channel something like $20,000,000; and there are others that will be needed before long if this theory is adhered to.

Again, recent studies of our water-supply show it to be in peril, and it is a serious question as to whether we can extend our intake tunnels out farther into the lake beyond the zone of danger, or resort to filtration of our supply. Yet we find our chief sanitary authorities helpless to appropriate any moneys for either of these purposes, although having (what the municipality has not) large taxing powers and an appropriate name.

In other words, it is a good old saying that "no man can serve two masters," and the requirements of commerce for Chicago, when carefully analyzed, do not seem to me to fit the requirements of modern sanitation.

Mr. Boardman is surely misinformed when he says I have opposed the Drainage Channel from its inception. As an accredited delegate to the Peoria Deep Waterways Convention of 1888, it was my privilege to help pass enthusiastic resolutions endorsing the Drainage Channel, and asking the national government to help us build it. Nobody quite knew what it would cost, but that did not seem to matter. At the same convention we heard about the *treming commerce* of the Upper Mississippi, that eagerly awaited an outlet to the Great Lakes. We were assured the Hennepin Canal was the way out.

I listened in amazement, finding it difficult to believe that so simple a remedy had not long ago been set in motion. We at once instructed the national government to begin that much needed improvement without delay, and I returned home, feeling proud of my services to my country, and a glow of pleasure in experiencing three days of Real Statesmanship: I was younger then than I am now.

Finally, I may say that if capable Sanitary District authorities, unhampered by the waterway entanglements, had had the seventy or eighty or hundred million dollars that will go into our Drainage Channel and its appurtenances before it is completed, to spend on sanitation projects, pure and simple, Chicago might to-day be the sanitary mecca of the world, instead of being on the eve of further great and necessary public-health expenditure. Nothing might have been too good for us with this amount of money: deep sewers, sewage purification, and pure filtered drinking water. We could have had a veritable "sanitary orgy," a carnival of "antiseptic delight," and besides, some money left over to sweep the streets with.

Respectfully submitted,

John W. Alvord.

Hartford Building, Chicago, Ill., Feb. 11, 1909.

[There is certainly much to be said on both sides of this question. We will not add to the discussion at present, except to comment briefly on Mr. Alvord's reference to the Berlin sewage farms. Presumably, Mr. Alvord intended this only to illustrate the uncompleted condition of the Chicago project. Berlin has some 40,000 acres of sewage farms. How large an area Chicago would require now or 20 years hence need not be discussed, but imagine the political and labor conditions involved in a sewage farm sufficiently large to care for immense volumes of sewage of any large American city! Sewage farming, for communities not already committed to it, is in disfavor to-day. It was considered for Chicago and dismissed as not advisable about sixty years ago, and was again dismissed just before the present dilution plan was adopted.—Ed.]

Notes and Queries.

In the article entitled "The Royal Prussian Testing Institute for Water and Sewage Purification," published in our issue of Jan. 28, a slight typographical error occurred in the third paragraph on page 116, where reference is made to "cooking" sewage sludge. This should of course have been printed "coking sewage sludge."

In the article on the Clinton Bridge of the Chicago & Northwestern Ry., in our issue of Jan. 21, it was stated that the plant for operating the swing span would include a Westinghouse storage battery. We are asked to state that this battery will be of chloride accumulator type manufactured by the Electric Storage Battery Co. The change in plan did not come to the notice of the author of the article before he corrected the proofs.

THE OPERATING COST OF THE BROOKLYN Bridge is found to be as high as $360,000 a year, according to an investigation made by the Comptroller of New York City. This figure is the average of ten years' maintenance and operating costs, beginning with 1898. In 1907 the cost slightly exceeded $400,000. The city's revenue from the bridge has exceeded $400,000 per year during the same period, and has always been larger than the cost until 1907, when there was a deficit of $3,250.

Report of the New York State Water Supply Commission.

The states of New York, New Jersey and Pennsylvania each have water-supply commissions created within the past few years. Each commission has more or less control over the taking of water for municipal purposes. In addition, the New York and New Jersey commissions are charged with certain duties relating to water storage and flood prevention. These duties are more comprehensive in the case of the New York Commission.

Some of the water-storage studies of the New York Commission were reviewed in our issue of April 30, 1908. The report of the New York Commission for the year ending February 1, 1909, has just been submitted to the Legislature. It consists mainly of the considerations of water storage for water-power purposes, but the sections dealing with the proposed Genesee River storage dam and reservoir take up in addition some important questions of flood prevention at and above Rochester. The report also contains the results of an important and valuable water-power analysis of the state.

The report is in three parts. Passing over Part I., which deals briefly with applications for permits to take water for municipal purposes, brief reference may be made to Part II., which deals with river improvement. This section is short, inasmuch as the cost of river improvements for land reclamation and flood prevention as discussed here would be met by assessments upon the property benefited, and the Commission has been unable to sell bonds which would be secured only by payment of individual assessments. Bonds for the proposed Canaseraga Creek improvement were first offered at 4% and subsequently, after obtaining legislative sanction, at 5%; but the bonds could not be sold at either rate.

Other work coming under the head of river improvement is confined to the Genesee River and is discussed in detail in a portion of the report dealing with water storage on the Genesee.

Water Storage and Power Development.

One of the several acts under which the State Water Supply Commission is carrying on its work directs it

to devise plans for the progressive development of the water-powers of the state for the public use under state ownership and control.

The act also directs the Commission to collect information on water-power.

The report takes up in considerable detail water-power studies which have been made on two tributaries of the Hudson (the Sacandaga and Schroon rivers), the Genesee, the Raquette rivers and the Delaware.

The engineering work of the first year of the Commission was organized and directed by Mr. John R. Freeman, M. Am. Soc. C. E., and the same engineer was retained during the past year as chief consulting engineer. The survey work of last year was in charge of Mr. Walter McCulloh, M. Am. Soc. C. E., as permanent consulting engineer of the Commission, and Mr. Horace Ropes, M. Am. Soc. C. E., as special deputy engineer.

THE HUDSON AND ITS TRIBUTARIES.—In taking up first of all the Hudson River, the report states that the value of that stream for navigation purposes has heretofore received so much attention that "its supreme importance as a power stream" has been overlooked. Nevertheless there are on the Hudson River, in the 65 miles between Troy and Corinth alone, 28 water-power plants with 100,733 HP. in use and a reported wheel capacity of 117,317 HP. This is 14% of the developed horse-power of the whole state. If in addition the Mohawk, Schroon, Sacandaga and other tributaries of the Hudson are taken into account, the Hudson River system is found to include 246,117 HP. already developed, or 30% of the total of the state.

Notwithstanding the early date at which some of this power was developed, the Hudson River has never been used to a large extent for the more refined manufacturing processes which flourish on the Merrimac and other New England streams. This is

largely ... little or nothing has ever been done to improve ... tural flow of the Hudson, which exhibits such ... ous fluctuations between its least and greatest ... rge that it cannot be relied on for the continu... e-power demanded by the finer manufacturi... esses and those which require more operati... r horse-power. Such irregularity of flow precludes ... use of the river for the production of hydraulic ... lectric power for industries of high character ... g large numbers of trained and intelligent operatives ... no constitute communities that add materially ... e population and wealth of the state. Even the ind... s which remain under these conditions suffer co... nterruptions. Such severe low-water conditions a... e prevailed during the past season are peculiarly ... strous to the efficiency of the plants on the Hudson ... h have been established to furnish electric power ... lighting and transportation in near-by cities.

Stream measurements at Mechanicsville from 1888 to 1907 [so in report; probably should be 1907], inclusive, show a maximum total annual yield for the Hudson River of 350,000,000,000 cu. ft. and a minimum yield of 186,000,000,000 cu. ft., or at the rate, for the yearly periods, of 11,090 and 5,910 cu. ft. per sec. The average monthly run-off for the same period was 30,900 and 1... cu. ft. per sec., maximum and minimum. The maximum daily recorded discharge on the Hudson River was 70,000 cu. ft. per sec., in the year 1869, but in the past season (1908) the daily discharge at Mechanicsville fell to 700 cu. ft. per sec.

Commenting on the minimum figure just noted, the report states:

It is reported that the insufficient heating of the street-cars passing the office of this Commission at the very moment this report is in preparation is due to the fact that the great power-stations which supply their motive energy from far up the Hudson are suffering from an abnormal shortage of water. Mills have been compelled to shut down or run on part time. Car schedules have been reduced, expensive temporary arrangements for the supply of power have had to be carried out and costly steam plants have been called on to supply the deficiency. All this is unnecessary in the present age of engineering skill and large industrial and public enterprises. The cost of equalizing the flow of this river, though apparently large is really small when compared with the enormous advantages which will be gained.

Studies of run-off records for a 14-year period indicate that to adequately control the river at Spiers Falls a total storage of 80,000,000,000 cu. ft. reservoir capacity would be required. This would give control of the 2,765 sq. mi. of drainage area above Spiers Falls, and the storage could be distributed between the Sacandaga, Schroon and Upper Hudson so as to figure 32, 16 and 32 billion cubic feet on each, respectively. To provide this vast amount of storage would require from 12 to 20 reservoirs. Ultimately, the Commission believes, the provision of this amount of storage would be economically justified.

THE SACANDAGA.—After stating the Hudson River case broadly, the report takes up in some detail studies for a large storage reservoir on the Sacandaga and for another one of the Schroon River. On the Sacandaga a dam site at Conklingville is proposed. At this point the variation in stream flow has been from 22,000 to 138 cu. ft. per sec., showing that to economically use any considerable part of the flow of this stream, large storage capacity is absolutely necessary. The river above Conklingville has a drainage area of 1,050 sq. mi., on which the average yearly rainfall is 49 ins. A reservoir could be built that would yield "an all-year-around day and night flow of 1,900 cu. ft. of water per sec." Such a reservoir, by proper treatment of its shores, could be made an attractive landscape feature, thus establishing "a health and pleasure resort within easy reach of centers of population," while at the same time materially reducing "the size and danger of floods that annually menace the Hudson Valley." In addition,

The water stored by the dam thus described will provide on the Sacandaga itself, by reason of the falls and rapids between the dam site and the mouth of the river, 75,000 HP., and will still add an average of 22,000 HP. during the six dry months of the year to the plants already developed on the Hudson below.

Or, if instead of installing a water-power plant at the dam the reservoir should be used for storage purposes only, it would add an average of 123,000 HP. to the plants on the Hudson during the driest month of the year, 105,000 during the second driest month, 74,000 during the third driest month, or an average of 100,000 HP. during the three driest months of the year.

As a result of conferences with mill owners, the Commission concludes that the latter would be willing to pay sufficiently for the power to "eventually insure a large revenue to the state."

The dam as proposed would be built of earth, with a concrete heart wall, 20 ft. thick at the base, extending above the flow line. Beneath the core wall, triple sheet piling would be driven. The dam would be about 95 ft. high from its base and 90 ft. above present low water, 110 ft. thick at the top and 1,400 ft. thick at the base, and its length would be about 1,200 ft. A spillway 800 ft. long, over solid ledge, would be provided. The dam would raise the water only 70 ft., and the top of the dam would be 25 ft. above the top of the spillway.

The cost of the dam and reservoir would be about $5,000,000, and the estimated cost of a power-house would be $3,853,000, or $51 per horse-power. On a 3% basis, the total interest charge for storage and power would be equivalent to $3.50 per year per horse-power, as compared with a probable $12 per year for coal to produce the same amount of power at this point. In addition, there would be the much smaller cost of maintaining a water-power as compared with a steam-power plant.

As a remarkable illustration of how the achievement of a great possibility may be prevented by a very small obstacle, we quote from the report as follows:

The fact that about 31 acres of state lands are included in the area proposed to be flooded prevents the construction of the Sacandaga project as above planned.

THE SCHROON.—The report next takes up storage on the Schroon. A dam 70 ft. high at Tumblehead Falls, costing some $2,000,000 for construction, land damages, etc., would increase the low-water flow of the Hudson River sufficiently to give at least 50,000 HP. continuously to the power plants now in use between the mouth of the Schroon River and Troy. Besides, 8,500 HP. on the Schroon would be created.

Here again an obstacle like that mentioned in connection with the Sacandaga effectually bars the scheme, as may be seen from the following:

However attractive the proposition thus outlined, it is impossible for it to be carried out under the present law of the state, since 25 acres of state lands included within the proposed flow line would be submerged. This barrier can only be removed by amending the Constitution.

THE GENESEE.—The Genesee River is next considered. A special appropriation of $25,000 was secured by the friends of this project, in order that complete studies might be made at once, thus avoiding the delays incident to the apportionment of the ordinary funds between the various parts of the state. The results of the Genesee studies are summarized as follows:

(1) The Genesee River above Portage has a watershed of 948 sq. mi.

(2) On the basis of the best long-time records available the average yearly rainfall in this watershed is found to be 39 ins.

(3) The mean annual run-off of the watershed above Portage is approximately 24,000,000,000 cu. ft. per year, which is equivalent to a discharge of 750 cu. ft. per sec. in the river at Portage.

(4) The proposed reservoir, if built with flow line at Elev. 1,210 ft. above sea level, would contain 18,000,000,000 cu. ft. of water, 11,250,000,000 cu. ft. of which would be available for commercial purposes. The reservoir would be 15 miles long and would average nearly 1 mile in width, with a total water surface of 13½ sq. mi., or 8,640 acres.

(5) The reservoir thus created would be capable under proper operation of controlling a flood equal to the severest one on record, namely, that of 1865. In addition to securing this high degree of river control the reservoir could be used to develop electric power at Portage to the extent of 75,000 HP. peak load, while at the same time furnishing water to maintain a flow in the Genesee River of such volume as would permit the existing power plants at Rochester to run throughout the entire year with water. At the present time these plants are compelled during the dry months to resort to the use of auxiliary steam power at an aggregate cost of approximately $130,000 annually. When it is considered that this benefit is entirely incidental to the original development of 75,000 HP. at the dam an idea may be gained of the importance to local industries which would result from the harnessing of the Genesee River, even leaving out of consideration the protection of the region from the present ills which result from the unrestricted flow of the river.

Alternative dam sites on the Genesee River were considered during the past year. It was found that by locating a dam farther down the river, on the so-called Rafter site, the construction cost would be only $1,711,000 against $3,487,000 for the dam previously considered. It appears that the only reason why the Rafter site was not considered first and solely is that the reservoir resulting from building a dam at that point would flood a portion of Letchworth Park. This portion, however, is said in the report to be outside the main part of the park and to have no esthetic value. The strip of land involved is about 200 ft. wide and extends upstream some 2,000 ft. It lies between the Pennsylvania R. R. and the east bank of the river. The Commission believes that instead of injuriously affecting the park,

a great dam at this point would constitute a monumental feature of the landscape which would greatly add to the present interest of the region. Furthermore, the regulation of the river flow resulting from the reservoir would suffice to maintain a flow over the beautiful Portage Falls during the summer months greatly in excess of the present minimum flow of the river at this point. This regulated flow would, of course, be constant, and the falls, instead of being injured, would thus be actually improved during the months when they are most visited.

The report also deals with the possibility of providing the desired storage and flood control by means of a number of small reservoirs on the headwaters of the river, instead of the one large reservoir proposed. Particular attention is given to this alternative on account of certain chance remarks made by Lord Kelvin during a brief stop at Rochester a few years ago. These remarks were made the subject of editorial comment in our columns in our issue of April 30, 1908, when we pointed out "that scientists with great names should be very careful what they say in subject," particularly when making off-hand remarks on technical questions likely to be involved in controversy.

The Commission found twelve small reservoir sites on the tributaries of the Genesee, but their combined storage capacity would be only 3,362,000,000 cu. ft. and the construction cost would be about $4,000,000. In contrast, the single dam proposed would store four times as much water at only one-fourth the cost per horse-power.

Finally, as regards the Genesee projects, the Commission expresses the belief that a market could be found for all the electrical energy that could be developed at the Portageville dam.

THE RAQUETTE.—The studies of the Raquette River made by the Commission indicated that an earth dam 4,000 ft. long at the foot of Tupper Lake, near the village of the same name, would raise the water levels of Big Tupper Lake, Simon Pond, Follensby Pond and the Stony Creek ponds, besides flooding 5,500 acres of swamp land. A reservoir with a flow line at Elev. 1,570 ft. above sea level and with provision for drawing down the water 20 ft. would give an effective storage of 11,770,000,000 cu. ft. out of a total of 14,720,000,000 cu. ft. of capacity. The surface area of the reservoir at flow line would be 24.7 sq. mi. and the total land area required for the project would be 26.6 sq. mi. This larger area, by acres, is divided as follows: Water surface of present natural ponds and lakes, 5,740 acres; swamps, 5,470; waste land, 250; woodland, 3,850; pasture and tillable lands, 480 acres.

FLOODING STATE LANDS.—Again there comes up the obstacle of flooding state lands, but in this case the area involved is large, being 4,380 acres. Comments on this subject may be quoted from the report as follows:

No one who has studied the site of the reservoir here proposed, either by personal inspection or by an examination of the accompanying photographs, could fail to be impressed by the great amount of swamp lands not only valueless but even harmful in their present condition which would be overflowed and made a part of the attractive lakes. The region is one of the most popular in the Adirondacks for summer visitors, and several widely known hotels as well as many private camps are found along the shores of these ponds. The destruction of the 5,470 acres of swamps could only have a beneficial effect on the value of this country as a pleasure resort, both by doing away with unsightly portions of the landscape and by removing to a large extent the present unhealthful and mosquito-breeding marshes.

However strong the prejudice in many quarters against reservoir construction in the Adirondacks, it must be admitted by any fair-minded person that certainly in this region there is a very great proportion of land which was almost literally "made to be flooded" and can serve no other useful purpose. This is true even of a large portion of the 4,380 acres of state lands included within the proposed flow line. Wishing to ascertain the exact value of these state holdings the Commission, through the courtesy of the Forest, Fish and Game Department, obtained the services of expert foresters to make a valuation of the timber on state lands within the reservoir line. The report made to this Commission estimates the value of the timber which would be flooded as follows: From Raquette Falls to Axton, $25 per acre; from Axton to Trombleee', $10. Along Raquette River there is practically no timber except a small quantity near the former point valued at $2.50 per acre; around Follensby Pond, $18 per acre; around Big Tupper Lake, $8 per acre and around Simon Pond, $4 per acre.

In general the timber on the land below the proposed flow line was found to be of practically no value throughout the whole extent of the state lands examined. On the other hand, between Elev. 1,550, the lowest point to which the reservoir will ever be drawn, and 1,570, the highest point to which it will be raised, the banks throughout the sections held by the state are so steep that only a small acreage could be covered and consequently only a small percentage of valuable timber destroyed. It is estimated that the total amount of timber on the state lands thus affected would not be over 1,470 acres, and its total value would not exceed $30,000.

Of the lands under private ownership which would be affected, probably the most valuable are those on the shores of Follensby Pond. The shores of this lake are largely included within the limits of a private preserve. It will be necessary for the state to acquire a strip around the shore of this pond averaging 150 ft. in width, and also swamp land amounting to a total of 730 acres.

It is interesting to note that the geological formation at this point is not favorable to rock foundation for the proposed earth dam. Prospect holes put down on the three alternative sites considered showed that rock was not reached within 100 ft. of the surface, "except at the sides of the valley, and even then only at certain points." A "very fine and fairly impervious sand" was found at the proposed dam site, and it is believed that with careful construction an earth dam could be built on this material with safety. The report points out that the earth dikes of the Metropolitan Water Board at Clinton, Mass., rested on a similar foundation. The following as to the sort of dam proposed here is of interest:

> The design of the dam suggested includes first the digging of a trench in the present mud and silt of the river bottom. From the middle of this trench sheet piling, consisting of planks in three tiers bolted together in such a way as to form a water-tight bulkhead, will be driven into the sand. The trench will then be filled with an impervious and tightly packed soil further strengthened by a curtain wall of reinforced concrete which will rise to the top of the dam and extend throughout its entire length. On this foundation and with a concrete core the earth embankment will be constructed to make a dam 60 ft. high, 4,000 ft. long and 100 ft. thick at the top. A masonry spillway on a solid rock foundation at the easterly end of the dam will discharge over the ledge which fortunately exists at that point. Provision has also been made for the necessary gates and sluiceways, including a log run.

The total fall of the Raquette River between the dam and the St. Lawrence is 1,400 ft. Of this, only about 300 ft. has been developed, and that only partially, giving a wheel capacity of about 50,600 HP. The flow of the river at Colton ranges from 300 to 1,800 cu. ft. per sec., and the ordinary maximum flow gives only 38,000 HP. The proposed reservoir would give 10,000,000,000 cu. ft. of storage, which would add 82,000 HP. to the power which can now "be realized continuously during the ordinary dry year, which includes all except one year in ten." The estimated cost of this project is $2,188,000.

Here again the fatal obstacle of state land is encountered, as may be seen from the following:

> In spite of the inviting character of this project and the benefit that would result to the state from the great supply of additional water power which could be cheaply developed, it cannot be undertaken because of constitutional prohibition against the flooding of state lands.

The reservoir project just outlined would give only half of the storage required for "adequate regulation" of the Raquette River. Additional reservoir sites have been found that would give additional storage of 9,000,000 cu. ft. These sites involve Little Tupper, Forked, Raquette, Blue Mountain, and a number of other lakes and ponds.

THE DELAWARE.—Opportunities for storage on the headwaters of the Delaware are not so favorable as on the other streams considered, but nevertheless the Commission report in detail several projects well worthy of attention.

Water Storage and Power Development as a State Policy.

New York may claim the honor, according to the Commission, of having anticipated the Federal Government in giving official attention to the formation of a definite policy of conservation of natural resources. This claim is based on statements made by Governor Hughes on Jan. 2, 1907, in his first annual message to the Legislature. He then urged that the undeveloped water-powers in the state forest reserves "be preserved and held for the benefit of all the people," instead of being "surrendered to private interests." He also suggested the desirability of formulating a comprehensive plan for water storage and water-power development. Accordingly, Chapter 569 of the Laws of 1907 was enacted, directing the Water Supply Commission to make studies for "the progressive development of the water-powers of the state under state ownership, control and maintenance for the public use and benefit and for the increase of the public revenue." About the same time the Governor withheld his approval of the legislative franchise for the St. Lawrence River Power Co. until the bill should be amended to provide, in the language of the report, "a substantial and increasing revenue to the state."

After such introductory remarks, the Commission reviews the magnificent water resources of the State of New York. Besides the streams already noted in our abstract above, and in addition also to the Niagara River, mention is made of the fact that the St. Lawrence River, an international boundary stream, has a total fall of 100 ft. as it passes the border of the state and is probably capable of furnishing 400,000 HP. Besides the larger streams, the Commission is of the opinion that it could eventually

> point out to owners of hundreds of small power sites economical and practical methods of storing flood waters on small streams and utilizing the energy to produce light, heat and power.

WATER-POWER CENSUS.—The total developed water-power of the state, by drainage areas, is found by a census taken by the Commission during 1908 to be as follows:

	Total stated HP. in use.
Erie, Lake	2,377
Niagara	145,790
Ontario, Lake	10,485
Genesee	18,063
Oswego-Seneca	34,340
Black and Salmon	78,890
St. Lawrence	86,108
Champlain, Lake	37,812
Hudson, Upper	143,415
Hudson, Lower	13,131
Mohawk	33,118
Housatonic	380
Delaware	3,068
Susquehanna	10,221
Allegheny	1,490
Total New York State	618,688

The developed water-power of the state, the Commission believes, might be increased to a total of 1,500,000 HP., exclusive of the Niagara and St. Lawrence rivers.

Further consideration is then given in the report to the relation of state lands and forests to water-power development, to which several references have already been made in our abstract. Early attempts to develop water-power within state-owned areas were opposed and thwarted by those deeply concerned in forest preservation, but this was largely due to the fact that "the element of public benefit was not the chief object" of the efforts to develop water-power. The attempts to preserve the forests against private encroachment have been eminently successful, and a constitutional provision secured in behalf of forest preservation has prevented the state from flooding forest lands, "no matter how worthless or unsightly." The total area of the state forest preserves that would need to be flooded to provide a system of storage reservoirs would not be over 20,000 acres, out of the total holdings of 1,277,000 acres in the Adirondack region. This would be [illegible] an 2% of the total, and of this 2%, three-[illegible]rs "is low swamp land and only one-quart[illegible] timber land."

Assuming an additional 1,000,000 H[illegible] possible under a rational system of wa[illegible]torage and power development, and using a [illegible]horse-power valuation of only $12 annual[illegible] it appears that "the annual earning capa[illegible] of the energy now running to waste in our [illegible]ms is $12,000,000." The $12 figure just cite[illegible]s the one set in 1902 by the old Water Sto[illegible] Commission. As compared with this, t[illegible] report states that $25 per horse-power was [illegible]d in a prospectus of a private water-power [illegible]elopment at Brattleboro, Vt., and that $20 [illegible] horse-power was the figure for the South[illegible] Appalachian streams set by Mr. M. O. Leigh[illegible], Chief Hydrographer of the U. S. Geological S[illegible]vey, in a recent report.

The direct value of the water-power [illegible]sibilities of the state would be greatly incre[illegible]ed by such incidental benefits as stimulus to [illegible]various local industries, and also fixed by the flood pre-vention, the benefits to navigation, the [illegible]protection to public water-supplies and to the forests, which would result. Flood damages, the report states, "affect no individual town or county," and the expense of flood prevention is beyond the resources of any "city or combination of cities." Thus, "river regulation for flood prevention" is a state function.

As to navigation benefits, the Commission mentions the shallow Hudson River channel between Coxsackie and Albany, which "has to be continually dredged on account of the deposits brought down in flood seasons." From 1797 to 1903 the federal and state governments and the cities of Albany and Troy expended $5,333,000 for the improvement of the Hudson River. Assuming a maximum channel width of 400 ft. for the critical portion of the river, it is estimated that the Sacandaga reservoir storage alone would increase the depth of the Hudson by nearly a foot. A notable forest benefit on account of water storage would be the provision of electric power as a substitute for steam power on the railways, thus doing away with a great source of fire danger in the forests.

REASONS FOR STATE CONTROL.—Private water-power development, the Commission states, "involves necessary limitations and wasteful methods." Needed cooperation between the various mill owners is arranged for with difficulty. The necessity of securing the greatest possible immediate returns on capital frequently results in the development of only the "cream" of a given waterfall. This not only leaves other portions undeveloped, but stops future "development by any other company or even by the state."

The state can afford to wait for returns, and, a far-seeing plan having been worked out, it can execute the plan in sections. Had there been a far-seeing plan adopted some years ago for the Raquette River, railways and lumbermen might have so located their lines and plants at Tupper Lake Junction as to have made possible the construction of the reservoir already outlined at a cost of a few hundred thousand dollars, instead of as many millions.

After giving careful consideration to the matter, the Commission has concluded that the State of New York should stop short with the conservation and control of water and water-power, leaving to private capital the building and operation of power plants and electric transmission lines.

Under the heading "Plan and Recommendations," the Commission gives first place to a consideration of such method of reservoir construction as would not cause "desolation" in the Adirondack preserves. Instead it suggests "a *proper* system of reservoir building—that will change ugliness into beauty and swamps into sanitary places." Heretofore storage has been the only consideration [with minor exceptions]. At the state dam at Indian Lake [the only example of state construction?] the treatment of the shore line "lacked that thoroughness necessary for satisfactory results"; but the artificial

pond kn... s Lake Kora shows on a small scale wh... ht be done, for this lake "has a shore li... attractive as that of any natural lake in t... oods."

The C... ssion proposes to rigidly fix high and low... levels and to thoroughly clear the area be... the two lines of all trees, stumps and bru... The slopes of most of the proposed Adirond... reservoirs being bold and either rock or... ly, it is expected that the thin soil would s... disappear, "leaving a bold and rocky shore o... clean, sandy beach exposed." Where needed, ... case of shallow flowage, "drainage ditches ... uld be constructed," thus preventing "swamp... ools" and giving "an opportunity for grass to grow, affording cover and protection for the wild life of the lake and wood." Spot Pond, forming a part of the water-storage facilities of Boston and vicinity, is cited as an example of "scientific treatment of the shore line of a reservoir."

The first steps to be taken by the state in a movement for developing its water-powers would be to amend the Constitution so as to provide a limited amount of flooding state lands and also to permit an increase in the bonded indebtedness that may be incurred by the state. On the subject of flooding the state lands, the report says:

By means of Section 7 of Article 7 of the State Constitution, a large part of the undeveloped water-powers of the Adirondack Mountains is locked up so tightly that the state itself cannot make use of its own. The section referred to reads:

The lands of the state, now owned or hereafter acquired, constituting the forest preserve as now fixed by law, shall be forever kept as wild forest lands. They shall not be leased, sold or exchanged, or be taken by any corporation, public or private, nor shall the timber thereon be sold, removed or destroyed.

The state owns 1,322,776 acres of land in the Adirondack park. On a conservative estimate not over 20,000 acres of such land, less than 1.6%, would be required to store the flood water of the Adirondack Mountain streams at all available sites; 15,000 acres, or 75% of the state land to be flooded is swampy; 5,000 acres are timber lands.

Private interests operating in former years in the Adirondacks, not content with destroying the timber on their own lands, were devastating the state's forests. Those interested in the preservation of our forests presented the matter to the Constitutional Convention of 1894 with the result that the present protective policy of the state was enacted.

To provide funds for water-power development, the Constitution now containing a prohibition which virtually prevents an appropriation of more than $1,000,000 a year for the purpose, a constitutional amendment is proposed which would authorize a bond issue not exceeding $20,000,000 "for the improvement of rivers by the building of storage reservoirs for the public welfare." The amendment would also authorize the Legislature to make provision for selling or renting power developed.

Four reasons are given why the state can carry out water-power projects more cheaply than can be done by private enterprise: (1) The state can borrow money at 3½%, against about 6 on the part of private enterprise, discounts, commissions and bonus considered; (2) the state can take a broad view of the subject, since it does not have to consider "quickest and largest possible dividends to satisfy the ambition of individual stockholders"; (3) the state can prevent the formation of monopolies of natural resources and can dispose of stored waters or develop power so as to both provide a revenue for the state and encourage industrial enterprises; (4) at present, private interests cannot condemn lands for water storage and power. While further legislation may be necessary for the purposes under consideration, the Commission believes that such legislation could be more easily secured than could that necessary to enable private concerns to take up the work. Finally, we may note that the Commission proposes, as a "workable plan" for developing its water-powers, that funds for the purpose be provided by means of 50-year state bonds. No project will be carried out until a petition has been received from prospective users of power, guaranteeing sufficient revenue to pay interest and sinking fund, maintenance and operating charges. It is proposed, however, that the actual charges for power would be fixed by public bidding. The plan provides for petitions contemplating the use of power in accordance with plans already developed by the Commission, and also petitions under which, if approved by the Commission, investigations and plans would be made.

The Need for Testing Trolley Wire.*

By CARL F. WOODS.†

No department of electric railroading has received less attention than the transmission line, and particularly the trolley wire. In the construction and maintenance of an electric railroad, no expense is spared to obtain power station equipment of the highest efficiency while the trolley wire, which is just as essential for operation, is generally purchased with no restrictions on the quality of material.

The entire development of electric traction has taken place within the past twenty-five years, and this short period of time has witnessed an almost fabulous advance in the improvement of power station and rolling stock. In spite of the great advance along all other lines, the trolley wire of to-day is not essentially different from that at first installed.

There are over 25,000 miles of electric railway lines in the United States; a total investment of some $8,000,000. This wire is the main artery of the entire system and any injury to it cripples the operation of the road and decreases the efficiency of the expensive generating equipment, and yet an examination of the records of roads operating many hundred miles of track shows that a broken trolley wire is almost a daily occurrence.

Numerous attempts have been made to specify the necessary characteristics of trolley wire. Some of these have failed because of an incomplete understanding of the demands upon the material and many more have failed on account of ignorance of the processes of manufacture, and the defects inherent to these processes.

The trolley wire in general use in the United States is made from hard drawn copper, the sizes and shape varying considerably, but circular wire having a diameter of 0.364 ins., corresponding to No. 00 B. & S gage, is perhaps the most common. Ordinary soft copper does not have sufficient strength for this service so that reliance has had to be placed upon either steel, bronze or hard-drawn copper. While steel wire has the requisite strength it is subject to severe corrosion from the weather and has greater electrical resistance. The silicon, phosphorus and other bronzes of a similar nature possess great strength, but all have the same defect of high resistance. Soft copper wire has a strength of about 34,000 lbs. per sq. in., while hard-drawn wire can be made having a strength of as high as 67,000 lbs. per sq. in. Hard drawn wire although possessing some serious defects has therefore been accepted as being much better than the other materials available for the purpose.

In standard construction, trolley wire is suspended in spans of 100 ft. on straight lines and in shorter spans on curves. These spans are supported by ears which vary in construction, but for the most part depend upon a fixed mechanical grip of the wire. In the earlier construction, ears were soldered to the wire, a process which annealed the hard drawn copper with the consequent reduction in tensile strength, but this practice is now rapidly becoming obsolete. The wire, therefore, is subjected to the pull of its own weight, to the ice and snow loads and to severe pounding from the trolley wheel. In addition, the wheel passing along the wire gives to it a wave motion which passes along the wire until an ear or other fixed support is reached where the wave is suddenly checked with a consequent sharp upward bend, followed by a series of bending stresses diminishing in force as the wave motion dies out. On a busy line where cars are operated on a small headway, the wire is subjected to practically a continuous effect of this nature, and in addition to this must be capable of carrying a large amount of power in order to diminish the outlay in feed wire.

To give efficient service under the conditions above noted, trolley wire must possess the following qualities:

(1) Conductivity.
(2) Tensile strength.
(3) Flexibility.
(4) Homogeneity.
(5) Toughness.

Each of these qualities is essential and yet no one of them can be increased beyond a certain point without a proportionate reduction of one or more of the others. For example, certain wires have been made from an alloy of copper and tin which have high tensile strength, great toughness and homogeneity, but are lacking in flexibility and have a conductivity only half that of pure copper. On the other hand, by proper drawing, wire can be made very homogeneous, flexible and tough, but lacking in tensile strength, the conductivity being unimpaired. To recapitulate, high conductivity is necessary for economical operation; tensile strength to withstand the abnormal loads; flexibility to enable stringing and to allow the wire to adjust itself under strains and blows; homogeneity that the stresses may be uniformly distributed along the wire and toughness to withstand kinking, wrenching and slow distortion, without giving way.

Attention naturally turns next to the methods of determining to what extent commercial wire possesses these essential properties. The determination of conductivity is very readily and accurately made with a Wheatstone Bridge or one of the several appliances based upon the same principle which are especially adapted for trolley wire. Tensile strength may be determined in a testing machine of suitable capacity, but owing to the nature of copper the elastic limit cannot be determined by a drop of the beam, as the metal apparently yields quite steadily up to the breaking point. Numerous conflicting figures are in print regarding the yield point of copper, but as a stress and strain diagram shows a nearly perfect curve, the actual elastic limit can only be accurately determined by applying increasing loads for a definite length of time and measuring the permanent set in each case. Such a procedure is obviously too complicated for commercial testing, so that the elasticity of the wire has to be judged by other means. Under ordinary circumstances, power to resist the effects of twisting is not necessary for conducting wire, but the torsional strength measures indirectly but accurately two of the most important mechanical properties that a wire can possess, namely, homogeneity and toughness. In a tensile strength test the maximum tensile load is largely a factor of the cross sectional area and the amount of work which has been put into the hardening of the surface. This tensile test will detect inferior drawing or inherent weakness of the copper, but it gives no idea of the power of the wire to resist distortion, nor of defects such as oxide seams which run lengthwise of the wire, and do not have a cross-sectional area of sufficient size to affect the breaking strength. With a torsional strain, however, such defects are quickly noted. If the wire contains an oxide seam as above spoken of, the twisting will open it up and at once weaken the strength of the wire. If the wire is of unequal hardness, the twists will tend to bunch up in the softest portion and very noticeably show this spot. Inferior copper not only shows a very low number of turns but splinters and slivers of metal appear on the surface which in very bad wires fall off to such an extent that a paper held beneath the sample during torsion will show a considerable collection of copper fragments. Non-homogeneous copper, due either to impure metal or uneven drawing, will show a great difference in the number of turns which different specimens will stand without breaking, while high grade metal which has been carefully drawn, twists evenly and uniformly, with no slivering and shows little difference in the number of turns on different specimens. It is, therefore, desirable to make at least three torsion tests, whereas one tensile strength test is sufficient to obtain an accurate measure of the strength.

In the appended Table I. are given a series of tests which clearly illustrate the four general divisions into which the trolley wire of commerce may be divided by reason of difference in physical qualities. Specimens A, B and C having tensile strengths of 5,500 lbs. or higher and torsion tests averaging about 13, represent wire lacking toughness which has been given a high tensile strength by drawing. Specimens D, E and F having tensile strengths around 5,300 lbs. and torsion tests of about 15 are wires lacking both toughness and surface hardness. Specimens G, H and I having tensile strengths of about 5,100 lbs., but torsion tests of approximately 23, are typical of wires in which the torsion has been obtained at the expense of tensile strength. Specimens X, Y and Z with tensile strengths over 5,400 lbs., together with torsion tests of 26 and even higher, represent the best trolley wire which can be made at a reasonable price.

Of these four classes there is again a distinction in that the first two represent copper of an inferior grade which cannot be made the equal of the wires of the last two classes by any treatment in the rod mill. On the other hand, wires of the last two classes are both made from excellent copper, although specimens X, Y and Z are wires greatly superior in all respects to the preceding three. It is interesting to note that all of these wires have practically the same conductivity which shows clearly the fallacy of attempting to value trolley wire by conductivity and tensile strength alone as is so frequently done. It is, therefore, necessary not only to obtain high grade copper, but also to secure the proper balance between tensile strength and torsion, as these two properties are correlated and increase in one, beyond a certain point, results in a proportionate decrease of the other.

The preceding remarks have shown the conditions under which wire must work and the qualities which are necessary to successfully meet these conditions. Attention must now be turned to the process of manufacture to determine how these qualities may be obtained and

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what defects of such processes injure the finished wire. For this purpose a brief review of the industry is necessary.

In the refining furnace the copper which is already at least 96% pure from the blister furnace is oxidized by air until a large part of the impurities have been removed and copper oxide is formed in considerable excess. Cuprous oxide is readily soluble in molten copper and acts as a powerful oxidizing agent by giving up its oxygen to any metallic bases present, so that an excess of oxide insures the presence of all metallic impurities in the oxide form. The excess cuprous oxide is then removed by burying a piece of green wood in the molten mass and covering the surface with charcoal. This process must be stopped within very narrow limits as over-reduction will throw the impurities back into the metallic state.

The influence of cuprous oxide has been studied by Mr. Patch, of the Detroit Copper Co.; by Dr. Elward D. Peters, Jr. (who is without doubt one of the best authorities on the metal in this country), and by the well-known German authority, W. Hampe, among many others. Many of the impurities in copper have been found to be much more injurious when present in the metallic state than when in the form of oxides, and one effect of the cuprous oxide, as above mentioned is to convert these impurities into the comparatively inert and harmless form and so improve the quality of the metal. In large quantities, however, cuprous oxide is known to harden copper while at the same time causing it to become short or brittle and, according to Hampe, the presence of 1% produces a diminution in toughness.

It is therefore possible to so treat low grade metal that it will have high conductivity although the large amount of cuprous oxide present greatly reduces the toughness. In purchasing copper for drawing trolley wire the manufacturer insists upon conductivity, but as a rule cares little for the other physical qualities, as he can obtain sufficient tensile strength by drawing. Lake copper possesses both high conductivity and excellent mechanical qualities, but this kind of copper costs from ⅛ to ¾-ct. per lb. more than electrolytic. Why the latter should be inferior to lake is difficult to explain, but experience shows that the general run of commercial electrolytic copper is by no means uniform in physical qualities and as a general thing is distinctly inferior to lake for wire drawing purposes. The cheaper price of electrolytic results in its use by many manufacturers although they frequently understand that the wire will be inferior.

The refined copper comes to the rod mill in bars weighing about 200 lbs. each, approximately ten of which are used in the manufacture of a mile of wire. These bars frequently have ridges along the sides, due to faults in casting and the surface is often covered with a layer of oxide. These bars are heated in a furnace until sufficiently soft for rolling and are passed through a series of rolls diminishing in size until a rod of the proper diameter is obtained. The rod is then cooled and drawn through dies, the rods being connected by brazing. The dies give the wire a dense hard exterior coating which increases its tenacity. As the strength obtainable is almost a direct factor of the work expended upon the wire, the smaller the size, the greater the tensile strength per square inch, so that the strength of the trolley wire is readily varied by changing the size of the rod and the number of dies.

One of the most serious defects occurring to wire at this point of the process is from ridged bars as above described. Ordinarily the bar will not be sufficiently heated to dissolve the copper oxide on the surface, so that as the softened bar enters the first passes of the rolls the ridges are lapped over, enclosing the oxide scale. The subsequent passes and the drawing through the dies obscure this flaw almost entirely, but it remains a serious menace to the toughness and the resistance to wear of the copper, as has been previously shown in remarks on the torsion test.

A second cause of trouble arises at the same point by overheating the copper in the furnace, in which case copper oxide is formed on the surface and quickly dissolves through the entire bar, thereby increasing the oxide content and tending towards the production of brittleness. Both of these dangers can be avoided by careful selection of the bars and by proper regulation of the temperature of the softening furnace.

As the proportion of the hard surface from drawing is at best a rather delicate operation, careless handling, uneven welding of the rods and unequal temperature of the wire while passing through the dies will all produce noticeable effects in the quality of the finished wire, so that care throughout the mill is absolutely necessary for the best results.

It therefore appears that the most efficient wire must possess not only high conductivity, but the maximum torsion and tensile strength possible in commercial copper and that to obtain this it is necessary first, to use high grade copper and to prevent an excess of cuprous oxide entering it at any stage of the manufacture and secondly, to select as perfect bars as possible and to observe extreme care in every treatment through which they pass. The question at once arises, can such wire be purchased at a commercial price? The writer must admit that this high-grade wire cannot be obtained at the ordinary market price, but requires the payment of a premium of ½-ct. per pound. To produce wire of this grade consistently the wire manufacturer must use the higher priced lake copper and observe unusual care in its treatment so that he is justified in demanding a higher price. Experience in the use of this wire has shown conclusively that it is well worth the additional cost.

Table II. gives the results obtained upon 13 consecutive miles of trolley wire made from selected bars of lake copper. The tests were made upon each mile of the wire and the results show the great uniformity obtainable with proper care. It should be said in this connection that this wire was not made as an experiment but was drawn by a certain wire company as a part of a regular business contract.

The point must be kept clearly in mind, however, that even the best of wire is of little value if improperly used, and the consumer must realize that the same degree of care which he insists upon from the manufacturer is essential in the handling and stringing of the finished wire.

The study of copper wire and the demands made upon it show the great need of a more thorough knowledge of this material. Owing to the minute quantity of impurities which exert a marked effect upon the qualities of copper, a chemical analysis is too difficult for technical purposes. The iron and steel industry is largely controlled to-day by microchemistry, and, in the same way, there is a future for this same practice in the copper industry. Of first importance, is the careful working out of the copper-cuprous oxide system with the determination of the number of phases occurring and the physical properties incident to different alloys. Doubtless much of this information is already in the hands of the copper refiners, but it remains for chemical engineers and chemists interested in industrial materials to verify and complete the work for the consumer.

TABLE I.—TEST RESULTS SHOWING CLASSIFICATION OF COMMERCIAL TROLLEY WIRE.

Sample No.	Diam., ins.	Torsion, turns in 10 ins.	Tensile load, lbs.	Conductivity, %.
A	0.365	14 12 9	5,650	98.4
		Av. 12		
B	0.364	11 12 11	5,550	98.6
		Av. 11		
C	0.362	18 14 16	5,500	98.2
		Av. 16		
D	0.365	18 16 18	5,260	98.6
		Av. 17		
E	0.365	14 15 16	5,270	98.7
		Av. 15		
F	0.364	14 13 14	5,370	98.7
		Av. 14		
G	0.364	21 23 22	5,070	98.9
		Av. 22		
H	0.364	22 25 21	5,110	98.4
		Av. 23		
I	0.365	24 25 24	5,210	98.4
		Av. 24		
X	0.364	27 30 28	5,400	98.3
		Av. 28		
Y	0.364	25 27 26	5,490	98.4
		Av. 26		
Z	0.364	25 28 25	5,590	98.2
		Av. 26		

TABLE II.—TEST RESULTS OF 13 CONSECUTIVE MILES OF HARD-DRAWN COPPER WIRE.

Mile, No.	Diam., ins.	Torsion, turns in 10 ins.	Tensile load, lbs.	Conductivity, %
1	0.363	22½ 24¾ 22½	5,470	99
		Av. 23½		
2	0.364	23 25 23	5,490	98.7
		Av. 23½		
3	0.363	19¾ 25½ 17½	5,400	97.8
		Av. 21⅛		
4	0.363	23½ 25½ 23½	5,470	98.8
		Av. 24		
5	0.363	22½ 21¾ 24	5,450	97.8
		Av. 22¾		
6	0.363	24 20 24¼	5,500	98.6
		Av. 22¾		
7	0.363	22½ 24 23¾	5,420	97.8
		Av. 23½		
8	0.365	23 24 20	5,510	98.5
		Av. 22		
9	0.363	24 19½ 23½	5,540	98
		Av. 22		
10	0.363	21 23 21	5,470	98.8
		Av. 21½		
11	0.363	22 22½ 23	5,490	98.8
		Av. 22½		
12	0.363	26½ 26½ 23½	5,500	98.5
		Av. 25½		
13	0.363	23 20½ 24	5,450	98.7
		Av. 22½		

THE FOREIGN TRADE OF THE UNITED STATES fell about $477,000,000 in 1908, as compared with 1907, the decline in imports accounting for $307,000,000 and the falling off in exports being $170,000,000. The foregoing figures relate to the full calendar year 1908. Details thus far available to the U. S. Department of Commerce and Labor apply to the first eleven months of the year, only. These eleven-month figures indicate that the heaviest proportion of the decline in imports was in diamonds and other precious stones, of which but $12,000,000 were imported in 1908 against $32,000,000 in 1907. It may be noted that of the heavy decline in imports of cotton manufactures ($72,000,000 to $50,000,000, or $22,000,000 in all), no less than $12,000,000 was due to the falling off of the imports in laces, edgings and embroideries, which fell from $37,000,000 to $25,000,000. Imports of iron and steel manufactures dropped from $37,000,000 to $18,000,000. Food-stuff imports showed but a slight decline, falling from $286,000,000 to $269,000,000. Some of the principal declines in imports are summarized as follows, in a bulletin issued by the above-named department:

Among the articles which show a marked decline in domestic exports in 1908 are iron and steel, of which the total exports in the eleven months ending with November, 1908, were but $139,000,000, against $182,000,000 in the same months of the preceding year; meat and dairy products, $164,000,000, against $184,000,000; wood and manufactures thereof, $66,000,000 in the eleven months of 1908, against $80,000,000 in the corresponding months of the preceding year; cotton, unmanufactured, $367,000,000 in the eleven months of 1908, against $392,000,000 in the corresponding months of 1907. Of breadstuffs, as a whole, show a decline in value exported, the total for the eleven months ending with November, 1908, being $179,000,000, against $187,000,000 in the corresponding months of the preceding year; though wheat alone shows an increase of about $10,000,000 in the same time, while corn shows a decline of about $23,000,000 in value.

A Novel Traction Engine.

An extraordinary type of traction engine is shown in the accompanying figures. The design originated with Mr. Benjamin Holt, of the Holt Manufacturing Co., of Stockton, Cal., in 1903, and has been evolved to its present state to meet conditions in this territory where the loose, dry soil of the desert country, the "adobe" clay of

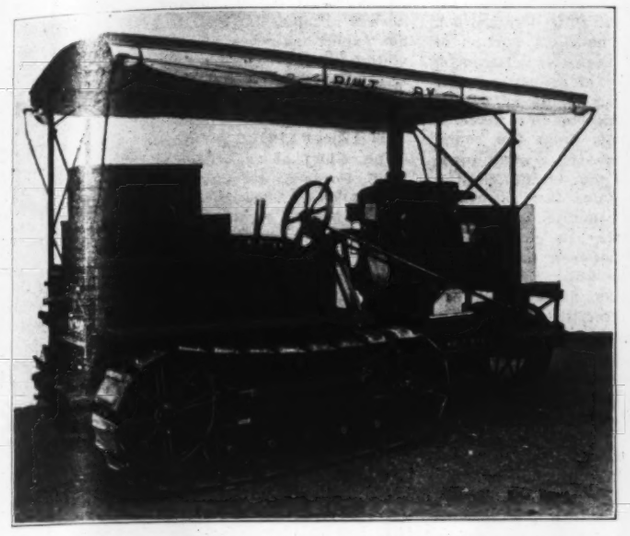

FIG. 1. A "CATERPILLAR" TRACTION ENGINE, BUILT BY THE HOLT MANUFACTURING CO., STOCKTON, CAL.

the Sierra Nevada foothills or the soft reclaimed lands of the islands bordering the Sacramento and San Joaquin Rivers, has to be contended with. The engine is popularly called a "caterpillar," from the appearance given through the use of the endless platform belt which replaces the large drivers of an ordinary traction engine. The "caterpillar" idea was first tried out on a steam type, but has since been adapted to the gasoline-motor drive owing to the demand for a gasoline traction engine where the adverse soil conditions prevail. The first steam "caterpillar" traction engine, which was built after three years spent in study and experimental work, was sent to Louisiana in 1906, to plow the rice fields. A similarity is seen here to the design worked out for snow locomotives, used in the Wisconsin logging districts, as described in Engineering News, March 14, 1907.

The striking feature of the Holt engine is the platform driving belt, best shown in Fig. 1. The belt is driven by the cast-iron rear sprocket, the front sprocket acting merely as an idler. The weight of the whole traction engine rests largely on five small wheels with short axles bearing in an intermediate truck frame. These wheels run on an endless linked track which carries pressed steel shoe plates coming in contact with the ground.

Power is furnished by a 40-HP., vertical, four-cylinder, gasoline motor, having 6 × 8-in. cylinders. The cylinders are water cooled and a radiator with its fan mounted on the front of the engine. A crank-shaft extension connects with the engine through a multiple disk friction clutch. A "planetary" reversing clutch is also provided.

The normal "low-speed" drive (about 2 mi. per hr.) is obtained from the shaft extension by bevel gears driving right and left countershafts which, in turn, drive the sprocket-wheel shafts through steel spur gears. What is called a "high-speed drive" is obtained through an auxiliary countershaft and four steel gears. The right and left bevel drive gears are connected to their respective shafts by friction couplings. Thus each traction belt is driven independently through friction connections. The drive sprockets for freighting engines are cast with rings for band brakes.

The height of the traction engine is 10 ft. 3 ins., over all. The width is 7 ft. 8 ins. The length is 17 ft. 8 ins. and the weight equipped is 7½ tons.

It is claimed that, in plowing, old adobe soil, holding alfalfa roots up to 1½ ins. in diameter, the engine has hauled 100 ins. of gang plows. On flat reclaimed lands, it is said, 12 ft. of plows have been dragged with a further trailing load of a harrow and seeder, while in sandy loam 15 ft. of plows, working to a moderate depth, have been carried. It is claimed that complete freedom has been secured from "bogging down" the engine in soft spots and from packing the soil. These engines have been used in freighting rock, cement, machinery and various supplies from railroad points to the ditch line of the Los Angeles Aqueduct, covering a trip of 4 to 12 miles across the Mojave Desert and up mountain trails having grades of 10 to 30%.

The low speed of 2 mi. per hr. is used when hauling a heavy load. The higher speed, 4 mi. per hr., is used with light trailing loads or when running empty. The fuel cost of these engines, with distillate at 9 cts. per gal., is given as somewhat under 1 ct. per HP.-hr. An engine, operating on the Mojave Desert line, made a series of hauls aggregating 113 miles on 225 gals. of distillate—a fuel consumption of 2 gals. per mile, at a cost of 18 cts. per mile. As a trailing load of 20 to 25 tons, made up of six tons of trucks plus the freight, may be hauled in loose soil the fuel cost per ton of freight hauled is roughly 0.7 ct. per ton-mile.

Fig. 2.

Fig. 3.

FIGS. 2 AND 3. A "CATERPILLAR" ENGINE PLOWING AND HAULING IN CALIFORNIA OCTOBER SOIL.

Annual Meeting of the Connecticut Society of Civil Engineers.

The 25th annual meeting of the Connecticut Society of Civil Engineers was held in Hartford, Conn., Feb. 9-10, 1909. The two days' session comprised a business meeting, an inspection of the new State armory and arsenal at Hartford, and the reading and discussion of nine papers. In addition to these technical proceedings there was held a very pleasing banquet at the Hartford Club, at which U. S. Senator Bulkeley, Mayor Hooker, of Hartford, and President Luther, of Trinity College, were the main speakers. At this banquet, President Luther made an especially strong plea for conservative designs. He said that while the average engineer has a wholesome respect for the laws of nature, there

Fig. 4. "Caterpillar" Engine Hauling Machinery Over a Steep Trail, Near the Mojave Desert, California.

are always some who, in the interests of a false economy or perhaps in a spirit of technical bravado, overstep the bounds of safe design and construction. These men should be condemned by the profession at large. And in the aiding of safe design, he thought it desirable that every engineer should use his individual influence toward the erection either by the government or by private means, of testing laboratories, well scattered throughout the country, so that more may be learned of the behavior of materials and structures.

The presidential address of Mr. E. W. Bush called attention to two matters, the problem of building roads to carry automobile traffic and the necessity for a more careful attention to the wording of realty deeds. This latter question was quite thoroughly discussed and as a result a committee was appointed to recommend, with the approval of the society, a bill to the Connecticut legislature regulating the manner of drawing up deeds of realty, particularly that part which relates to the description of the land. The committee appointed last year to consider the laws on drainage area reported progress and was continued. It was then voted that the Connecticut delegation in the Federal Congress be urged to advocate the passage of the bill for the construction of a 11,000-ton testing machine (described in Engineering News, Feb. 11, 1908,

p. 166). This practically finished the business portion of the convention; the remainder of the time was taken up with papers.

Technical Papers.

REINFORCED-CONCRETE IN THE CONNECTICUT STATE ARMORY.—The State of Connecticut has now under construction and nearly completed a new arsenal and armory in the city of Hartford, which for size is surpassed by only two others in this country, and for beauty and equipment has few equals. The building comprises a drill-hall, 184 × 270 ft. in plan, flanked on either side at one end with the head houses in which the offices and recreation rooms of the armory are placed. The main roof trusses and their supporting columns are of steel and the face of the whole building is of irregular stone ashlar, trimmed with concrete block, but the remainder of the structural parts are of concrete, plain or reinforced. This concrete work was the subject of a paper by Mr. B. W. Morris, the architect of the building.

While the whole framework of the office portion of the building is of reinforced concrete there is nothing of exceptional design there except possibly the placing of certain of the columns so that a maximum of clear floor space could be had. On this account a line of columns is made to support floor beams on each side, which latter extended as cantilevers from the column and are stiffened at their ends by minor non-bearing columns. The whole floor of the drill hall is of concrete; a slab supported on plain concrete columns.

The two most interesting portions of the work are the cast concrete blocks on the face wall and the concrete roof slabs. The face blocks are used in cornices, belt courses and trims around the whole building. They were cast on the ground in plaster molds, which were shaped to size and tooled so as to form a block ready for use in the wall. Not only are the ordinary molds and quoins used but in a number of places quite decorative pieces have been placed. This molded work has the appearance of a good limestone and contrasts well with the rougher main face stone. The roof slabs are of cinder concrete, reinforced with mesh and flats, and cast on the ground. The slabs, each 2½ ins. thick, 12 ft. long and 24 ins. wide, were hoisted into place on the roof purlins, locked together by an open joint poured with concrete and the whole covered with roofing compound. In a test one of these cinder concrete slabs stood safely a test load of 175 lbs. per sq. ft., supported as it would be in the roof.

It is worth noting that the State Commission for the construction of this building contains two civil engineers, one in actual practice and the other connected with a large manufacturing company.

CONCRETE SEWERS.—Three papers on sewers were presented. The first, by Mr. Henry J. Kellogg (New Haven), described the State St. overflow sewer recently completed in New Haven. This is a rectangular conduit 15 ft. wide and 6 ft. high, with two openings each 6 × 4 ft. It is built of concrete walls, floor and roof, reinforced with rods, and is supported at intervals of 3 ft. on pile bents driven into the soft ground over which it passes. The most interesting part of the construction is where the sewer passes under the platform of a railway station, at a place where present conditions prevented pile driving and prospective trackage made heavy construction necessary. At this place a pile pier or abutment was driven on each side of the platform, and on these piers the sewer was built spanning 33 ft. otherwise unsupported. In this span the walls were thickened and the reinforcement increased.

The next paper, by Mr. R. N. Clark (Hartford), on "Tunnel and Concrete Sewer at Hartford," enumerated the various concrete sewers that have been built in that city, but devoted most of its attention to the description of a sewer built in tunnel through a stiff clay. Mr. Clark also showed a model of a collapsible wooden sewer mold, which was used with great success on the constructions referred to. This mold was made by a regular carpenter and, so far as was stated, is not under patent.

The last of the sewer papers was by Mr. J. F. Jackson (New Haven) on "Costs of Sewer Work." This consisted entirely of tabular matter which, when published in the annual proceedings of the society, will be of undoubted value, but which cannot be abstracted here.

REINFORCED-CONCRETE ROUND HOUSE.—A paper by Mr. G. M. Poley (Waterbury) on the "Reinforced-Concrete Locomotive House at Waterbury" was read by Mr. F. J. Easterbrook (New Haven). This round house, a portion of the new work of the New York, New Haven & Hartford R. R. at Waterbury, at present consists of 10 stalls, each comprising about 8° of the circle, and is connected at one end to a machine shop, into which locomotives from the round house tracks may be run, via the central turntable. The house consists of four circumferential rows of hooped concrete columns carrying beams and roof slabs of reinforced concrete. The smaller circumference, or the entrance, is closed in by large rolling wicker doors between the columns and the outer rim by large glass windows directly in line with the tracks, filled in between with brick walls, so as to offer little obstruction to a possible uncontrolled locomotive.

The columns and their connecting girders were cast in place, but the intermediate beams and the roof slabs were cast on the ground and afterward placed, locking the extending reinforcement and filling the joints with wet concrete. Other points of interest in the round house are the asbestos lumber smoke jacks, permanent compressed air jacks under the tracks to remove trucks which can then be slid into a transverse pit and thence into the machine shop, steam pipes to each pit for removing ice and snow from the locomotives, and an indirect hot-air heating system.

THE ENGINEER IN COURT.—Under the above title Mr. E. W. Bush read a paper which outlines some of the difficulties the engineer has with the law, either as an expert witness or as a litigant. He said that every engineer should keep a daily record of the work under his charge just as though he expected the details of each day's work to be made the subject of future dispute. Nothing is of more value in any legal case than exact signed and dated records of actual progress of construction. After passing over some of the standards of conduct of the expert witness on the stand, Mr. Bush took up the question of extra compensation to the contractor for work claimed to be outside of the contract. Often at the end of a long-time job the contractor will put in a claim for extras, which was not even hinted at the time the work was done. The engineer may not have the information at hand regarding the details of these extras, and so in many cases is forced to pay for the work, a payment that might be avoided if he were notified of the intention of the contractor in time to collect evidence on his side of the case. To avoid this difficulty, Mr. Bush suggested the following clause to be added to all long-time contracts:

*** * * And before any monthly payments are made to the contractor, he shall sign and deliver to the party of the first part the following declaration:**

I hereby declare that during the month of [*month just past*], [*year*], I have not performed any work, furnished any materials, sustained any loss, delay or damage, or otherwise done anything for which I shall ask, demand, sue for or claim compensation from [*party of the first part*] in addition to the regular items of prices set forth in contracts or contract dated (_____), and executed between myself and [*party of the first part*] except as I hereby make claim for additional compensation as set forth on the itemized memorandum herewith attached.

(Signed) _____,

(Date) _____

In discussion it was thought that this addition to the contract would be admirable provided that a contractor could be persuaded to sign one so amended, which was extremely doubtful. If the quit-claim provision should be removed and the contractor merely required to sign monthly bills of extras there might be more chance of his accepting the provision. The further discussion turned on the proper behavior of the expert engineering witness. It was agreed that the hardest part of the expert's duty is in impressing upon his own lawyer just what q[uestion] asked so that the true opinion could be brought out. Next to th[e] the entanglements set by the opp[osing] It is rather curious to note that th[e] the society, in discussing this qu[estion] to regard the whole matter of expe[rt] testimony as a fight between the la[wyer] engineer, the latter representing truth which the former attempts It was forgotten that, unfortunately always absolute and that in every c[ase] has expert witnesses of equal integ[rity] viction. By arrogating to himself [the] session of knowledge and truth, the [engi]neer can hardly expect to make a successful [wit]ness.

OTHER PAPERS.—A paper by M[r.] McGarvie Cline, Chief of the Office of Wood [Uti]lization, U. S. Forestry Service, on "Conserv[ation] in the Use of Wood," described the work of [the] Service in the testing of the strength and [pre]servation of the woods of this country. Mr. Herbert C. Keith (New York), in a paper entitled "Stray Thoughts on Bridge Design and Maintenance," gave the results of his personal inspection of more than a thousand bridges of all kinds in this and other countries. Among other things he said that dirt and consequent dampness destroy more bridges than poor design and construction, that the danger from electrolysis on bridges is greatly overestimated and that the commercial steel of to-day has not the lasting qualities of the wrought iron of 25 years ago.

The final paper, read by title only, was "An Efficient Indexing System," by Wm. Gavin Taylor (Waterbury).

Officers.

The following officers were elected for the ensuing year: President, Frederick J. Easterbrook, New Haven; First Vice-Pres., S. B. Palmer, Norwich; Second Vice-Pres., C. A. Ferry, New Haven; Sec. and Treas., J. Frederick Jackson, New Haven.

The society is showing its customary regular increase in size and is maintaining in excellent fashion its financial stability.

AN EXPLOSION IN THE WEST STANLEY COAL mine at Durham, England, Feb. 16, imprisoned about 135 miners. The shaft is about 700 ft. deep and was so much damaged by the explosion that rescuers cannot descend into the workings until extensive repairs have been made.

THE NASHVILLE-MEMPHIS EXPRESS on the Illinois Central R. R. was wrecked Feb. 16 near Carbondale, Ill. Three persons were killed and about 40 others injured, some fatally. The entire train left the rails and the three crowded passenger coaches were overturned. The accident is ascribed to a broken rail.

A VIOLENT WIND STORM swept over New York City, New Jersey, Delaware and Eastern Pennsylvania Feb. 10. Hundreds of buildings in Newark, Philadelphia, Wilmington, and a number of other towns and cities were unroofed and otherwise damaged by the storm. In spite of the violence of the gale, which is said to have attained a velocity of 70 mi. per hr., reports have been received of only three deaths of which it was the cause.

A FREIGHT TRAIN on the Louisiana Ry. & Navigation Co.'s line was derailed on a trestle near Baton Rouge, La., Feb. 14, and fell 35 ft. to the ground. One man was killed and six others injured. The locomotive was running backward and the tender struck a cow, causing the derailment and destruction of the entire train of 20 cars.

NIAGARA FALLS was made nearly dry, on the American side, Feb. 14, by a great wall of ice which was piled up between the head of Goat Island and the American bank. This was caused by a heavy northeast wind which held back the river and prevented the clearing of the ice until a gorge was formed. It is reported that the Horseshoe and the Canadian Falls had also been so encroached upon that the usual appearance of the whole region was changed. The only previous cases of this phenomenon said to be recorded were on Mar. 29, 1848, and March 22, 1903. The power plants on the American side of the Niagara River are reported to have been greatly interfered with.

THE BITTER ROOT TUNNEL or St. Paul Pass Tunnel of the Chicago, Milwaukee & Puget Sound Ry. (the Pacific extension of the Chicago, Milwaukee & St. Paul Ry.) has been completed through, the heading meeting on Feb. 9, according to information received from Mr. E. J. Pearson, Engineer of the Lines West. Connection of the [illegible] lines showed practically exact junction, the difference in levels being only 0.01 ft., and in alinement [illegible] ft. In the last month of the work very rapid progress was made; the length of full-section excavation in both ends during January was 750 ft.

THE CONSTITUTIONALITY OF THE U. S. RECLAMATION Act has been affirmed by the U. S. Circuit Court of Appeals at San Francisco in the case of the United States vs. Haynes. The point at issue had no particular engineering interest, but the decision is considered of great importance, in view of the fact that the constitutionality of the Act was questioned in the decision of the U. S. Supreme Court in the Kansas-Colorado case involving an interstate stream.

FILTERED WATER for the whole of Pittsburg, save the recently annexed Allegheny section, became available on Feb. 4 by connecting the original Pittsburg municipal system with the mains of the Monongahela Water Co. The property of this company has been or is about to be taken over by the city, as noted on page 87 of our issue of Jan. 21, 1909. The Allegheny district is still supplied with unfiltered water, but an extension to the filtration plant is proposed, in order to give it as well the benefit of filtration.

A FALLING-OFF IN TRAFFIC ON THE GREAT Lakes is noted in the report for the calendar year 1908. The volume of traffic on the Great Lakes during 1908, as measured by domestic shipments of merchandise from the various lake ports, was 60,518,024 net tons, compared with 83,506,991 and 75,609,648 net tons shipped during the 1907 and 1906 seasons, respectively. The considerable decrease in the 1908 total was due mainly to the smaller shipments of iron ore, though the shipments of all other principal items, except hard coal and salt, also show smaller totals than a year ago. The iron-ore shipments by lake during the year, exclusive of 228,784 gross tons exported to Canada, totaled 24,939,185 gross tons, compared with 40,727,972 gross tons reported for the 1907 season. The greater part of this ore, namely, 20,444,751 gross tons, was received at Lake Erie ports; the rest is credited mainly to Chicago, Indiana Harbor, Gary, Milwaukee, and Detroit. About a million gross tons of ore are credited to the two new receiving points of Indiana Harbor and Gary. Iron manufactures also fell below the 1907 record.

Domestic grain shipments by lake during the past season aggregated 111,213,910 bushels, of which 57,754,183 bushels constituted wheat, 22,546,795 bushels corn, 15,701,406 bushels oats, 13,516,156 bushels barley, and 1,695,370 bushels rye. The total 1908 grain movement by lake shows a 22.8% decrease from the 1907 total. The largest relative loss of almost 50% is shown in the shipments of corn. The lake shipments of oats declined about 24%, while lake shipments of other grains likewise show perceptible decreases as compared with 1907 totals. Rates on grain were decidedly lower than in 1907. The 1908 shipments of flour, 1,188,831 net tons of 10 bbls. each, likewise present a smaller total than for the preceding year.

The annual lumber shipments, 944,742,000 ft. B.M., were 32% below the total reported for the year 1907. Hard coal shipments were slightly in excess of the 1907 figures but those of soft coal fell off some 12%. The rates for each were about the same as last year.

The total domestic receipts by lake during the year 1908 aggregated 58,900,345 net tons. About 73% of the total merchandise tonnage received is credited to twelve ports. For the year 1908 the largest tonnage received is shown by Chicago, closely followed by Buffalo, which held first rank as a receiving port during the year 1907. The shipments appear to be less concentrated, the 12 ports in question shipping less than 59% of the total tonnage. Notwithstanding the considerable decrease in ore shipments for the past season, Duluth shows by far the largest tonnage of domestic lake shipments, followed at some distance by Superior, West Superior and Buffalo. It should be noted that the figures just given comprise only domestic shipments, the aggregate weight of exported goods not being recorded by the custom houses from which the Bureau of Statistics obtains its record of foreign commerce.

The vessel movement on the Great Lakes during the year in question also shows a considerable decrease compared with 1907 figures. The total departures in the domestic trade numbered 65,624 vessels, of 83,378,323 net tons, compared with 73,769 vessels, of 99,166,409 tons, reported for the calendar year 1907. The average size of the vessels plying on the Great Lakes was 1,271 tons, compared with 925 tons for the year 1902 and 1,100 tons for the year 1905.

The above information is a part of the advance report of the U. S. Department of Commerce and Labor.

A FIREPROOF BUILDING for the U. S. Geological Survey and other bureaus of the Department of the Interior has been made the subject of letters addressed to the House of Representatives by the Secretaries of the Treasury and Interior Departments. It is estimated that a fireproof building for this purpose, including vaults and heating and ventilating apparatus, could be built for $2,500,000. The buildings now occupied by the Survey are described as "inadequate, unsuitable and unsafe" and as giving rise to "unhealthful conditions and the necessary use of artificial light," and further as hampering "the transaction of public business" and causing "a real loss in the efficiency of the public service." It is said that

even on the brightest days 131 members of the survey work only with the aid of artificial light, and on cloudy days this number is increased to 420. The lack of a natural light not only seriously affects both the quality and the quantity of the drafting, engraving, microscopic and other technical work, which form so important a part of the Survey's activities, but the injurious effect upon the eyesight is a matter of experience with a large percentage of those engaged in certain classes of work.

The constant danger of fire in these buildings presents the most urgent ground for consideration of this estimate. An inventory of the public records and other property exposed to this danger at the present time aggregates over $4,500,000, with the following items:

Manuscript maps, reports, illustrations, notes and records in process of preparation for publication	$1,514,000
Permanent records, including stream-gaging records, mine maps, and other data not replaceable	1,250,000
Library and catalog	520,000
Maps in process of engraving	380,000
Engraved plates	634,000
Instruments and apparatus	157,000
Engraving and printing equipment and supplies	75,000
Publications—reports and maps	196,000
Miscellaneous office equipment	114,000
	$4,840,000

A fire which threatened the contents of the building now used by the Survey was recorded in our issue of Dec. 24, 1908.

A RADICAL IMPROVEMENT IN HIGH-SPEED steel is claimed by Jonas & Colver, of Sheffield, England. They say that they are able to make cutting steel having three to six times the edge endurance of the best present high-speed tool steel. The new steel is hardened in water or oil. Its discovery is said to have been brought about by litigation against the firm for infringement of the Taylor-White patents on steel which acquires great edge endurance by high heating and air hardening.

BATTLESHIP MAINTENANCE COST during the past year, found by averaging the cost of current repairs on 17 United States battleships during 1908, amounts to $110,000 per year per ship. This does not include the more extensive repairs or overhauling. The coal cost for the vessels was $5,545,000, of which about 40% is due to transportation and storage. These figures were given by the Secretary of the Navy in reply to inquiry by the Senate.

ILLUSTRATED HEARINGS before the House Committee on Irrigation were recently held at Washington, thus, so far as we know, introducing a new feature in Congressional hearings. The purpose of these particular hearings has been to set forth the progress of the engineering work of the U. S. Reclamation Service. At the hearing on Feb. 2, Mr. E. G. Hopson, in charge of the Pacific Coast Division, and Mr. Christian Anderson, Project Engineer in charge of the Okanogan project, Washington, appeared before the Committee.

THE DISCHARGE OF SEWAGE and other polluted matters into lakes and ponds having an area of 1,000 acres or more lying wholly in the State of Vermont is prohibited by an act of the Vermont Legislature, approved Jan. 27, 1909. The act will take effect Oct. 1, 1910. The range of penalties for violation of the act is from $200 to $20.

A RAILWAY HEALTH EXHIBIT is being prepared by the State Board of Health of California. Arrangements have been made with the Southern Pacific Co. to furnish a car for transportation over its lines of railway, and it is expected that the Santa Fe will supply like accommodations. The following partial list of things to be included in the exhibit has been kindly supplied us by Dr. N. K. Foster, Secretary, California State Board of Health, Sacramento, Cal.:

Models of kitchen operating room, room ventilation, isolation room, ventilation room (oil heater), sand filter, garbage "pit and cone" incinerator, septic tank for private home, butcher shop and tenement above, room prepared for disinfection, tent, frame, screen tent, sleeping porch, window sleeping canopy, Fort Stanton model sleeping shack, polluted surface well, polluted lake water (relief map), summer hotel showing dangers from typhoid, polluted surface stream water (relief map), dairy and farm house.

In addition, there will be an exhibit from the Pure Food Laboratory; another from the Bacteriological Laboratory, and also a small exhibit of insects which have to do with the transmission of various diseases. The insect exhibit is being prepared by Prof. R. W. Doane, of the Department of Entomology and Bionomics of Leland Stanford University. Prof. Doane has kindly written us the following regarding his exhibit:

I am showing several of the common mosquitoes of the state, distinguishing between those forms that carry malaria and yellow fever and those that, so far as we know, do not disseminate disease. I am also showing a small case of flies, house-flies, stable-flies and others, and pointing out how they may carry various diseases. I am also showing a few charts giving enlarged drawings of some of these insects, showing something of their structure and life-history. I am also showing a few ticks, fleas and bed-bugs, which are also concerned in carrying disease.

THE ACREAGE OF LAND UNDER IRRIGATION during the calendar year 1908, in the projects of the U. S. Reclamation Service, which are now being operated, is given by the "Reclamation Record" as follows:

AREAS ACTUALLY IRRIGATED DURING THE SEASON OF 1908.

State.	Project.	Acres.
Arizona	Salt River	115,000
Arizona-Colorado	Yuma	3,800
California-Oregon	Klamath	9,378
Colorado	Uncompahgre	15,000
Idaho	Minidoka	24,464
Idaho	Payette-Boise	55,000
Kansas	Garden City	5,558
Montana	Huntley	4,400
Nebraska-Wyoming	North Platte	23,220
Nevada	Truckee-Carson	27,450
New Mexico	Carlsbad	8,000
New Mexico	Hondo	1,500
New Mexico-Texas	Rio Grande (Liasburg)	17,000
North Dakota	Buford-Trenton	1,200
North Dakota	Williston	2,000
Oregon	Umatilla	2,500
South Dakota	Belle Fourche	5,000
Washington	Okanogan	1,353
Washington	Sunnyside	42,000
Wyoming	Shoshone	2,600
Total		367,023

U. S. RECLAMATION SERVICE PROJECTS were in the following stage of construction on Feb. 1, 1909, according to the "Reclamation Record":

	Per cent. Completed.
Arizona, Salt River Project	76.5
Arizona-California, Yuma Project	64
California, Orland Project	28
California-Oregon, Klamath Project	36.7
Colorado, Grand Valley Project	2.5
Colorado, Uncompahgre Project	67.7
Idaho, Minidoka Project (gravity system)	100
Idaho, Minidoka Project (pumping system)	47
Idaho, Payette-Boise Project	93
Kansas, Garden City Project	97.8
Montana, Blackfeet Project	8
Montana, Flathead Project (preliminary work).	
Montana, Milk River Project	6
Montana, St. Mary Project	18
Montana, Sun River Project (Fort Shaw Unit 99% completed).	6
Montana, North Dakota, Lower Yellowstone Project	89
Nebraska-Wyoming, North Platte Project	73
Nevada, Truckee-Carson Project	90
New Mexico, Carlsbad Project	99.8
New Mexico, Hondo Project	99.8
New Mexico, Rio Grande Project (Eagle Dam preliminary work Leasburg Diversion)	100
North Dakota, Buford-Trenton Project	38
North Dakota, Washburn project (preliminary work.)	
North Dakota, Williston Project	64
Oregon, Umatilla Project	84.25
South Dakota, Belle Fourche Project	64.5
Utah, Strawberry Valley Project	31
Washington, Okanogan Project	84
Washington, Sunnyside Project	30
Washington, Tieton Project	49
Washington, Wapato Project (preliminary work)	
Wyoming, Shoshone Project	42.5

PRESERVATION OF LOBLOLLY PINE telephone poles by a creosote treatment has been demonstrated by the U. S. Forest Service, cooperating with the North Louisiana Telephone Co. Such success in protection against decay, at a low cost, has resulted that a concern has been incorporated under the name of the Louisiana Creosoting Co., to operate commercially the plant designed by the Forest Service. The treating plant, which has been in operation since the latter part of October last, is of the non-pressure or "open-tank" type. The installment of this style of plant has been shown by articles in Engineering News, Oct. 22 and Dec. 31, 1908. The plant used in the experiment with the North Louisiana Telephone Co. is equipped with a horizontal treating cylinder 50 ft. long and 6 ft. in diameter. It was designed by the Forest Service, whose representative also supervised the construction and operated the plant for several months. During this period, 3,000 poles, 2,500 cross-arms and 500 ties were treated, an amount sufficient to determine the most economical methods of treating these classes of material. The Forest Service then withdrew and the plant is now being successfully operated by the owners according to reports issued by the Forest Service.

THE COLLAPSE OF STAGING in a dry-dock of the American Shipbuilding Co. at Loraine, Ohio, Feb. 10, dropped seven workmen to the bottom of the dock. The men fell about 100 ft. and three were killed outright, the others being seriously injured. Reports state that the accident was due to the weakening of the staging by a high wind.

THE BLACK DIAMOND COLLIERY, of the Haddock Coal Co., at Wilkes-Barre, Pa., was heavily damaged by fire Feb. 11. Two men were killed and three others injured by suffocation, and the fire also caused the death of 22 mules stabled in the mine. The fire started in the emergency hospital near the foot of the shaft.

A BROKEN AXLE caused the wreck of one of the cars of the Pittsfield (Mass.) Electric Street Ry. Feb. 11 on Wahconah St. in that city. One passenger was killed and ten injured. At the time of the accident, the car was descending a long grade. As it neared the foot of the grade, the front axle of the forward truck snapped in two. The car left the rails and the rear end swung around ahead of the front striking an electric light pole and breaking it off short. The car was crowded, containing about 80 people, and the man killed was in the rear vestibule.

THE 18-HOUR TRAIN of the Pennsylvania R. R., bound from Chicago to New York, was partially derailed Feb. 15 by a small landslide in a deep cut near Newton Hamilton, Pa. The train was running through the cut at a speed of about 45 mi. per hr. and a fog prevented the engineer from seeing the obstruction in time to avoid the collision. The air brakes were applied and the engine reversed just as the train struck the landslide. The locomotive, combination car and two sleepers left the rails but remained upright. Only one person, a baggage man, was injured.

A FIRE IN THE FLORES THEATER AT ACAPULCO, Mex., Feb. 14, caused the death of between 200 and 250 people. The fire started from the film of the moving picture machine. On account of the special performance in honor of the Governor of the State of Guerrero, the theater was overcrowded and the three narrow exits were entirely inadequate to permit the escape of the audience of about 1,000 persons. The theater was a wooden structure and was completely burned. It was impossible to identify the dead on account of disfigurement by the fire, but it is stated that no Americans were among them.

A SECOND BERGEN HILL TUNNEL OF THE LACKawanna in Hoboken, N. J., was opened on Sunday, Feb. 14. The tunnel is double-track, like the old one, and is parallel to the latter about 30 ft. c. to c. south of it. The tunnel has a length of about three-quarters of a mile, and is in sound trap rock. Where lining was necessary concrete was used. This tunnel gives the Delaware, Lackawanna & Western Ry. four tracks from its Hoboken terminal to Dover, N. J., via the double-track Morris & Essex line and the double-track Boonton branch. Hitherto the tunnel formed a throat which reduced the capacity of the line, a matter felt very seriously during the morning and evening commuter periods.

THE FREIGHT-CAR SURPLUS decreased slightly between Jan. 20 and Feb. 3, 1909, being on the latter date 301,571 cars, a decrease of 10,093. About 16,500 box cars went back into service, but 6,000 coal cars became idle.

THE "MAURETANIA," mammoth transatlantic turbine steamship of the Cunard Line, is reported as having established a new record for a single day's run of 671 knots (772 land miles) between noon, Feb. 13, and noon, Feb. 14, on her present westward trip. This gives an average speed of 26.84 knots per hour for the day. The best previous record, held by the sister ship "Lusitania," was 650 knots for the day ending Aug. 17, 1908. The best previous record of the "Mauretania" was 637 knots.

AN ILLINOIS WATERWAY COMMISSION, to have charge of the expenditure of the $20,000,000 waterway bonds recently voted by the people of that state, is provided for by a bill which has been introduced in the legislature by Mr. Frank P. Schmitt, Chairman of the Senate Committee on Waterways. The bill provides for the construction of a navigable deep waterway or canal from the power plant of the Chicago Sanitary District at Lockport to the Illinois River at or near Utica, Ill.; together with the power plants, locks, dams, bridges, etc., necessary for the utilization of the water-power along the waterway. The bottom width of the canal is to be not less than 200 ft., and the depth not less than 14 ft. The construction, management and operation are to be under the control of a board of five commissioners to be appointed by the governor for a term ending in 1915, their successors to be appointed for terms of six years. Such commissioner is to be required to give a bond for $25,000, and will receive a salary of $5,000 per year, except that the chairman will receive $7,000. The bill provides that water-power may be leased at any point on the canal for a period of ten years, only, but leases may be renewed.

Personals.

Mr. Olaf Hoff, M. Am. Soc. C. E., has opened an office at 149 Broadway, New York City, and will engage in a general engineering practice.

Mr. Benjamin Guggenheim has become President of the International Steam Pump Co., succeeding Mr. John W. Dunn, who resigned on account of ill health.

Mr. James L. Tighe, M. Am. Soc. C. E., City Engineer of Holyoke, Mass., has been elected a member of the Institution of Civil Engineers.

Mr. Charles Lohman, Superintendent of the Chicago, South Bend & Northern Indiana Ry., has resigned and has been appointed Assistant General Manager of the Buffalo & Lake Erie Traction Co., with headquarters at Erie, Pa.

Mr. A. B. Lueder, for the past nine years Superintendent of Erection with the American Bridge Co., of New York, has left that position and is now associated with the Merrill-Ruckgaber-Fraser Co., Contracting Engineers, 50 Church St., New York City.

Mr. William A. Card has been appointed Division Superintendent of the Chicago, Burlington & Quincy R. R., at Creston, Iowa, succeeding Mr. A. W. Newton, M. Am. Soc. C. E., who will return to Chicago as General Inspector of Permanent Way and Structures.

Mr. W. E. Smith, City Engineer of Webb City, Mo., has resigned to become General Manager of the Engineering Construction Co. of Kansas City. Mr. Smith will begin work for the construction company at Purcell, Okla., in charge of sewer construction.

Mr. Frank L. Getman, Assoc. M. Am. Soc. C. E., formerly Deputy State Engineer and Surveyor of New York, has recently moved to Havana, Cuba, to become Office Engineer for the Cuban Engineering & Contracting Co., which has in hand the construction of the new Havana sewer system.

Mr. P. N. Jones, Assoc. Am. Inst. E. E., formerly Electrical and Mechanical Engineer of the Pittsburg Railways Co., has been made General Superintendent, succeeding Mr. John Murphy, who has become Assistant to the President. Mr. Jones graduated at Ohio State University in 1892 with the degree of M. E. in E. E.

Mr. Frank Trumbull, President of the Colorado & Southern Ry. and the Colorado Midland Ry., has resigned. Mr. Daniel Willard, Second Vice-President of the Chicago, Burlington & Quincy R. R., is now President of the Colorado Midland, and Mr. Geo. B. Harris, President of the Burlington, is President of the Colorado & Southern.

Mr. Edward G. Acheson, M. Am. Inst. E. E., President of the International Acheson Graphite Co., of Niagara Falls, N. Y., received, on Feb. 12, the degree of Doctor of Science from the University of Pittsburg. The degree was conferred in recognition of his many successes in scientific research. Mr. Acheson originated the methods of producing commercially carborundum, siloxicon and artificial graphite, and is an acknowledged expert in the use of the electric furnace.

Obituary.

John C. Williams, President of the Forest City Steel & Iron Co., at Cleveland, Ohio, died at that city, Feb. 8. Mr. Williams was born in Maryland in 1830.

Russell Sturgis, architect and art critic, formerly President of the Architectural League, died Feb. 11 at his home in New York City. Mr. Sturgis was born in Baltimore Co., Md., in 1836 and graduated from the College of the City of New York in 1856, with the degree of A. B. He received the degree of M. A. from Yale in 1870. He was Professor of Architecture at the College of the City of New York from 1878 to '80, and in 1893 received the degree of Ph. D. from that institution. His architectural training was gained in offices in New York City and in Munich, Bavaria. Mr. Sturgis designed Yale Chapel and the Farnham and Durfee dormitories at New Haven. He was a pioneer in the use of fireproof building materials, being the builder of the Mechanics' and Traders' Bank Bldg., at Albany, N. Y. The greater part of his work as a practicing architect was completed before 1880. Since that time he has devoted himself to writing and to his work as an art critic. He edited the "Dictionary of Architecture and Building," was editor for decorative and fine art for various popular dictionaries and encyclopedias and has written more than five hundred articles on art, architecture and art criticism. Mr. Sturgis was a member of the American Institute of Architects, the National Academy of Design and various other organizations.

Engineering Societi[illegible]

COMING MEETINGS.

AMERICAN INSTITUTE OF MINING E[illegible] ...NEERS.
Feb. 23. Annual meeting at New Hav[illegible] ...onn. Secy., R. W. Raymond, 29 West 39th St., [illegible] ...York City.

NORTHWESTERN CEMENT PRODU[illegible] ...ASSOCIATION.
March 2-4. Annual convention at Mi[illegible] ...polis, Minn. Secy., J. C. Van Doorn, 836 Secur[illegible] ...Bank Bldg., Minneapolis, Minn.

INTERNATIONAL MASTER BOILER M[illegible] ...ERS' ASSOCIATION.
April 27 to 30. Annual meeting at [illegible] ...isville, Ky. Secy., H. D. Vought, 95 Liberty St., [illegible] ...York City.

RAILWAY SIGNAL ASSOCIATION.
March 15. At Chicago, Ill. Secy., C[illegible] ...Rosenberg, Times Bldg., Bethlehem, Pa.

AMERICAN RAILWAY ENGINEERING[illegible] ...ND MAINTENANCE OF WAY ASSOCIATION.
March 16-18. Annual convention at Ch[illegible] ...Ill. Secy., E. H. Fritch, 962 Monadnock Block, C[illegible] ...go.

AMERICAN SOCIETY OF CIVIL E[illegible] ...NEERS.—At the meeting held in New York City, Fe[illegible] ...7, a paper, entitled "The Operation of Passenger El[illegible] ...rs," by R. P. Bolton, was presented for discussion. [illegible] ...paper appeared in "Proceedings" for December, [illegible]

MONTANA SOCIETY OF ENGINEERS.—The twenty-second annual meeting was held at Gre[illegible] ...Falls, Montana, Jan. 7-9. Among the papers presented were the address of the retiring President, Mr. Archi[illegible] ...E. Wheeler and papers on "Hydraulic Tables," by Josep[illegible] ...H. Harper, and on "The New York Barge Canal," by Theron M. Ripley. Mr. Ripley's paper was accompanied by a large map and numerous blue prints, showing the route and methods of construction of the canal.

NATIONAL GOOD ROADS ASSOCIATION.—An Illinois convention was held at the Auditorium Hotel, Chicago, on Feb. 12, with a very small but interested attendance. After an address by the President, Mr. Arthur C. Jackson, an address on "National Aid for Good Roads," was given by Mr. H. H. Gross, Secretary of the Farmers' Good Road League. He advocated the furnishing of financial assistance by the Federal Government and the taking up of road improvement as a national policy. It is of interest to note that the present movement in favor of improving waterways was classed as of secondary importance and for the benefit of local interests only, while good roads are of universal importance. If any waterway advocate had been present there might have been an interesting discussion as to the relative importance of transportation by waterway and by highway. An address was made also by Mr. J. C. Bartholf, Secretary of the National Good Roads Congress, who advocated a Lincoln memorial highway from Chicago to Springfield. This idea did not meet with much support, and was attacked as being of benefit only for automobile traffic. Mr. Gross considered that the money and work could be spent to much better advantage in improving the roads in agricultural districts.

An address on "Existing Laws and Needed Legislation for Good Roads in Illinois" was given by Mr. Arthur N. Johnson, Assoc. M. Am. Soc. C. E., State Highway Engineer. In Illinois, the towns are as a rule far apart and there is no interurban traffic on the roads. The traffic census shows that the traffic decreased rapidly with the distance from the towns. In such eastern states as Massachusetts and New York the towns are closer together and there is enough interurban traffic to warrant the construction of state-aid road systems. In Illinois, Wisconsin and Missouri, the work of the state is mainly advisory, to inform the local authorities as to proper methods, but leaving each community to take care of its own roads. Unfortunately, there is a general impression that no skill is necessary in building and maintaining roads, in fact maintenance is practically ignored.

The Illinois State Highway Commission undertakes to give advice and technical assistance in road building. It supplies broken stone when necessary, the stone being crushed, screened, etc., by convict labor at the Joliet penitentiary. This does not conflict with private interests, as it is distributed where no suitable road material is procurable locally, and where otherwise no such material would be used at all. The state also furnishes a steam roller and an engineer to direct the work of the local labor employed. Material sufficient for about 110-miles of road has been distributed to various localities, where the local authorities have made application to the State Commission. The cost of transportation of this material promised to be a problem at one time, but the Interstate Commerce Commission has decided that for hauling material for public use under the direction of public authorities the railways may make special rates and need not post them in the way required for commercial rates. It is now proposed to establish other stone crushing plants (for convict labor) at places where they would not come into competition with free labor, thus facilitating the distribution and reducing the cost and delay of transportation.

Resolutions were passed in favor of petitioning the Illinois Legislature for the state-aid system; approving of the present use of convict labor in preparing road material; and urging the establishment of three more quarries or distributing points throughout the state.